THE

ARTILLERIST'S MANUAL.

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LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET
AND CHARING CROSS.

THE

ARTILLERIST'S MANUAL,

AND

BRITISH SOLDIER'S COMPENDIUM.

BY MAJOR F. A. GRIFFITHS,
R. F. P. ROYAL ARTILLERY.

"Si quid novisti rectius istis,
Candidus imperti: si non, his utere mecum."

TENTH EDITION.

Published by Authority.
Vide Memorandum, Horse Guards, 13*th October,* 1856.

PUBLISHED BY PERMISSION OF THE LORDS COMMISSIONERS OF THE ADMIRALTY,
6TH JANUARY, 1868.

PART IX.—NAVAL GUNNERY.

LONDON:
W. CLOWES & SONS, CHARING CROSS;
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1868.

"*Horse Guards,*
"* *Memorandum.* *13th October*, 1856.

"His Royal Highness, the General Commanding in Chief, strongly recommends to the Officers, and Non-commissioned Officers of the Army, the Revised edition of a Work, entitled 'THE ARTILLERIST'S MANUAL, AND BRITISH SOLDIER'S COMPENDIUM,' a work replete with the most useful Military information, and of which Major Griffiths, R.F.P., Royal Artillery, is the author.

"By command of His Royal Highness,
The General Commanding in Chief,
(Signed) G. A. WETHERALL, *Adj.-General.*"

QUEEN'S REGULATIONS, 1857.

"*Note.* Page 119.

"Officers, and Non-commissioned Officers, are also recommended to provide themselves with a work entitled 'THE ARTILLERIST'S MANUAL, AND BRITISH SOLDIER'S COMPENDIUM,' by Major Griffiths, Royal Artillery."

*** With reference to the foregoing *Memorandum*, Copies of the Tenth edition will be supplied to Non-commissioned Officers, and Privates, throughout the whole of the British Army (Volunteers included) at the reduced price of Five shillings per copy, on applications from Officers commanding Regiments, Corps, and Detachments, addressed to Major F. Griffiths, R.F.P., Royal Artillery, St. Mary Bourne, Andover, Hants.

PREFACE.

Tenth Edition.

I HAVE been aware for a considerable time that there was a demand for another edition of "THE ARTILLERIST'S MANUAL, AND BRITISH SOLDIER'S COMPENDIUM," and gladly would I have responded to the gratifying call; but the alterations in, and additions to various portions of the armaments in the two services were so frequent, and the struggle for supremacy between guns, parapets, iron shields, &c., was so fierce, and so interminable (and even still is so) that I was unwilling to record the various results, until approved patterns were officially sealed, and successful inventions, and improvements were promulgated.

Moreover, the revision of "Field Exercises, and evolutions of Infantry;" Rifle exercises; Carbine, Pistol, and Lance exercises; Sword exercise; the introduction into general service of breech-loading Small-arms; the revision of the tables of Ordnance, and Carriages, and an infinitude of changes in *Materiel*, &c., have been so important and extensive that I delayed the publication of the present Work, until it could be satisfactorily completed as a Compendium of theoretical and practical military science, to meet the requirements not only of the Army (*Vide Memorandum*, dated Horse Guards, 13th October, 1856), as well as of the Royal Navy, obligingly encouraged as it has also been by the Lords Commissioners of the Admiralty (*Vide* NAVAL GUNNERY, Part IX.).

It is scarcely necessary to detail all the additions and alterations in the present Edition. Comparing it with former publications, a zealous student will readily ascertain them; but *inter alios*, attention should be directed to the undermentioned alterations, and additions:—

Exercise, and Evolutions of Infantry. Rifle exercises. Bayonet exercise. Sword exercise. Carbine exercise. Pistol exercise. Lance *exercise.* Weight, and dimensions of Muzzle loaders, and Breech *loading Arms.*

Small arm ammunition. Cartridge, Ball; Boxer, Snider, converted Enfield Rifle.

Boxes for packing Ammunition. Barrels, and Cases.

Weight, and Tonnage of Carriages in the Service.

List of Service Guns, and Ammunition. Nature and Number of Rounds of Ammunition carried by Rifle batteries. Laboratory stores. Combustible compositions. Hydroscope. Mantlet, iron. Adapters. Machine, rocket. Rockets, War; Life serving. Sights, for Bronze guns, Howitzers, Carronades, Land service sights. Sea service sights. Wood tangent scale. Hexagon brass slides. Wood slides. Pontoons.

Penetration of the principal pieces of Ordnance. Filled cannon cartridges, Rifled ordnance; Smooth bore ordnance.

Cartridges, Ordnance, dimensions, &c.

Shells, smooth bore Ordnance, Diaphragm, Boxer.

Charges, bursting, approximate, shell. Shot, solid, cast iron. Grape.

Armstrong guns. Projectiles.

NAVAL GUNNERY. "Notes on Naval guns, their stores, and fittings."

Naval carriages; common, and rear chock.

Cases powder, metal.

Ranges for Armstrong guns.

Charges, and projectiles for Rifled guns, and for Smooth bore guns.

Positions of batteries. Revetments. Fascines; gabions; Fougasses. Stockade.

Defence, and attack of Posts.

Cum multis aliis.

The PARTS are not quite similarly numbered to those in former editions, the chief portion of the information specially adapted for the service of the Royal Navy, being introduced in PART IX.

Two new Plates, and a considerable quantity of additional matter, will evince my desire to render the Manual worthy the gratifying reception it has hitherto received, from its first publication in 1839 to the present time; in which period *Nine* large editions have already been circulated throughout all ranks of the Army, and Navy; and civil Engineers have also consulted the portion of the Manual having reference to their *scientific profession.*

The old Artillerist acknowledges with just pride, and grateful feel-

ings, that the *Motto* of this publication, "Si quid novisti rectius istis, candidus imperti: si non, his utere mecum," has been most fully responded to; the Military and Naval authorities having most considerately, at all times, aided in the revision, and improvement of the Manual; and my esteemed friends and brother officers having readily contributed the valuable information required from their several Departments, and Factories.

This will probably be the last edition of the Manual that I shall myself be able to compile, and publish; but I fervently trust the Work will not become extinct; as I shall at my death bequeath it as an Artillery legacy to my Son, Captain Leonard Griffiths, Royal Artillery; who, for several years has been intimately acquainted with my literary exertions, and has materially assisted in the publication of our Work, especially in the present edition.

The experience, and credit my dear Son acquired in the Crimean campaign, will guarantee the successful continuance of a Compendium that has been most liberally encouraged by the Authorities, and has been cordially received by all ranks in the British United Services. "*Vive; Vale.*"

Frederick Augustus Griffiths.

PUBLICATIONS,

referred to, or extracted from.

Field exercise, and Evolutions of Infantry.
Sword exercises.
Carbine exercise.
Pistol exercise.
Lance exercise.
Manual of Artillery Exercises.
Manual of Field Artillery Exercises.
Armstrong Guns, *Land service*, Observations, &c.
" *Sea service*, Instruction.
Veterinary directions. Royal Artillery.
Instruction for the exercise of great guns on board Her Majesty's Ships.
Notes on Naval Gunnery.
Naval Gunnery . . . . Lieut.-General Sir H. Douglas, Bart.
Fortification . . . . Lieut.-General Sir C. Pasley, K.C.B.; Mr. Landmann.; Mr. Lochée.; General Malorti.; Maj.-General Sir J. Jebb, K.C.B.; Captain Macaulay.
Elementary Course of Field and Permanent Fortification, by Captain G. Philips, Royal Engineers.
Military Surveying, &c. . . Lieut.-Colonel Basil Jackson.
The Horse, with a Treatise on draught.
Mathematics . . . . Dr. Hutton.; Dr. O. Gregory.; &c., &c., &c.
Practical Geometry . . . Mr. Landmann, &c.
Natural Philosophy . . . Dr. Fergusson.
The Practical Mechanic's Guide.
The Practical Engineer's Guide.
The Engineer's, and Contractor's Pocketbook.
Tables . . . . Mr. Beardmore.

PLATES.

CONTENTS.

IRON ORDNANCE. *Smooth bore.*

RANGE, ELEVATION, CHARGE, &c.

MORTARS.

AMMUNITION, PROJECTILES, COMBUSTIBLES, IMPLEMENTS, &c.

COMBUSTIBLE COMPOSITION.

LABORATORY STORES.

PART IV. ARTILLERY EXERCISES. SERVICE OF HEAVY ORDNANCE.

NAVAL CARRIAGES.

PART X. BATTERIES, AND FORTIFICATION.

THE

ARTILLERIST'S MANUAL,

AND

BRITISH SOLDIER'S COMPENDIUM.

PART I.

ARMS, AND AMMUNITION, IN THE BRITISH SERVICE.

SMALL ARM AMMUNITION.

Dimensions of Boxes.

Length, 1 ft. 4 in., including the cleat. Depth, 8⅝ in. Breadth, 7¼ in.

Weight of Boxes.

Empty, 7 lb. 6 oz.

Contents, and Weight of Barrels and Boxes.

	Barrel.			Box.		
	No. of Cartridges.	No. of Caps.	Weight filled.	No. of Cartridges.	No. of Caps.	Weight filled.
			lbs. oz.			lbs. oz.
Rifle Musket, Pattern 1842	500	750	78 4	..	..	..
Rifle Musket ,, 1853	700	1050	75 8	440	640	51 8
Artillery Carbine . . .	750	1200	79 8	440	640	50 4
Victoria Carbine . . .	*700*	*1050*	69 0	..	..	..

WEIGHT, AND DIMENSIONS, &c.,

Muzzle

	Description of Arm.	Musket.			
		Weight.			
		With		Without	
		Bayonet, or Sword.			
		lbs.	ozs.	lbs.	ozs.
1	Cavalry Rifle Carbine, Pattern 1861 (*a*)	..		6	11
2	Royal Artillery do. Pattern 1861 (*a*)	9	4	7	8
3	Royal Engineer do. Lancaster	9	0¾	7	6¼
4	Naval Rifle, Pattern 1858 (*b*)	10	14	8	8
5	Long Enfield Rifle, Pattern 1853 (*c*)	9	12	8	14½
6	Short do. do. Pattern 1856 } For Serjeants and Rifle Corps.	9	14½	8	2½
7	Ditto do. do. Pattern 1860 } For Serjeants and Rifle Corps.	10	4	8	8½
8	Whitworth Rifle, Pattern 1862.	10	10¾	9	13¼
9	Whitworth Short Rifle, Pattern 1863.	11	9¾	9	14
10	Westley Richards' Breech-loading Carbine.	..		6	8
11	Sharpe's do. do. do.	..		7	7
12	Terry's do. do. do.	..		6	3½
13	Cavalry Rifle Pistol, 8 inch	..		2	10¼
14	Ditto do. 10 inch	..		3	2
15	Deane, and Adams' Revolver Pistol, 54 Gauge (*e*).	..		2	6½
16	Colt's do. do. 84 gauge (*e*)	..		2	9½
17	Deane, and Adams' do. 38 gauge (*e*)	..		4	7½
18	Naval Smooth-bore Pistol	..		2	3½

(*a*) There are a Cavalry Rifle Carbine and an Artillery Rifle Carbine, Pattern 1856. Both these Carbines have only 3 Grooves, with a Pitch of 1 in 78. In other respects they are the same as those of Pattern 1861.

(*b*) The Naval Rifle has a "*Cutlass Sword-bayonet.*"

(*c*) Previous to December, 1859, the Stocks of the Enfield Rifle, Pattern 1853, were 1 inch longer in the Butt than the present pattern. Several long Butt Stocks are therefore still to be met with.

OF ARMS, AND AMMUNITION.

Loaders.

Musket. Length. With Bayonet, or Sword.	Musket. Length. Without Bayonet, or Sword.	Bayonet, or Sword. Weight.	Bayonet, or Sword. Length beyond Muzzle.	Bayonet, or Sword. Weight of Scabbard.	Barrel. Dimensions, &c. Weight.	Barrel. Dimensions, &c. Length.	Barrel. Dimensions, &c. Diameter of Bore.
ft. in.	ft. in.	lbs. ozs.	ft. in.	ozs.	lbs. ozs	ft. in.	in.
..	3 0¾	..	..	..	2 9¾	1 9	·577
5 3	3 4¼	1 12	1 10¾	12	3 0	2 0	·577
5 11½	3 11½	1 10½	2 0	9¾	3 9	2 7½	·577
6 3⅜	4 0½	2 6	2 2⅞	10¼	4 1½	2 9	·577
5 11½	4 6	0 13½	1 5½	4½	4 4	3 3	·577
5 11¼	4 0½	1 12	1 10¾	7½	3 10½	2 9	·577
5 11¼	4 0½	1 11½	1 10¾	7½	4 1½	2 9	·577
5 9	4 3½	0 13½	1 5¼	4½	4 15½	3 0	·451
5 11¼	4 0½	1 11¾	1 10¾	7½	5 0¾	2 9	·451
..	2 11⅞	..	..	..	2 5	1 8	·451
..	2 11½	..	..	..	2 8½	1 6	·551
..	3 1⅜	..	..	..	3 0	1 9	·539
..	1 2	..	..	..	0 15¼	0 8	·577
..	1 3¾	..	..	..	1 4½	0 10	·577
..	1 8	..	..	..	Solid. (d)	0 5¾	·434
..	1 1¾	..	..	..	0 11	0 7½	·358
..	1 11⅝	..	..	..	Stock and (d) Barrel in one.	0 7½	·470
..	0 11⅝	..	..	..	0 12¼	0 6	·570

(*d*) In Deane, and Adams' Pistols, the Barrel and Stock being in one, the Weight of the Barrel alone cannot be given. These Pistols, as well as Colt's, and the Cavalry 8-inch Pistol, have no Back Sights.

(*e*) In the Revolvers the Gauge is measured by the number of Spherical Bullets to the Pound.

WEIGHT, AND DIMENSIONS, &c.,

Muzzle

Description of Arm.	Barrel. Grooves. Number.	Width.	Depth. Muzzle.	Depth. Breech.
		in.		
1 Cavalry Rifle Carbine, Pattern 1861 (*a*) .	5	·235	·005	·013
2 Royal Artillery do. Pattern 1861 (*a*) .	5	·235	·005	·013
3 Royal Engineer do. Lancaster . . .	Oval Bore.			
4 Naval Rifle, Pattern 1858 (*b*)	5	·235	·005	·013
5 Long Enfield Rifle, Pattern 1853 (*c*) . .	3	·235	·005	·013
6 Short do. do. Pattern 1856 } For Serjeants and Rifle Corps.	3	·235	·005	·013
7 Ditto do. do. Pattern 1860 } For Serjeants and Rifle Corps.	5	·235	·005	·013
8 Whitworth Rifle, Pattern 1862	6	·196	·037	·037
9 Whitworth Short Rifle, Pattern 1863 . .	6	·196	·037	·037
10 Westley Richards' Breech-loading Carbine.	8	..	·008	·008
11 Sharpe's do. do. do. . . .	3	·214	·013	·013
12 Terry's do. do. do. . . .	5	·175	·013	·013
13 Cavalry Rifle Pistol, 8 inch	5	·235	·005	·013
14 Ditto do. do. 10 inch	5	·235	..	·013
15 Deane, and Adams' Revolver Pistol, 54 Gauge (*f*).	3	·305	·009	·009
16 Colt's do. do. 84 gauge (*f*) . .	7	·08	·010	·012
17 Deane, and Adams' do. 38 gauge (*f*). .	3	·016	..	..
18 Naval Smooth-bore Pistol	..	..	..	..

(*a*) There are a Cavalry Rifle Carbine and an Artillery Rifle Carbine, Pattern 1856. Both these Carbines have only 3 Grooves, with a Pitch of 1 in 78. In other respects they are the same as those of Pattern 1861.

(*b*) The Naval Rifle has a "*Cutlass Sword-bayonet.*"

(*c*) Previous to December, 1859, the Stocks of the Enfield Rifle, Pattern 1853, were 1 inch longer in the Butt than the present Pattern. Several long Butt Stocks are therefore still to be met with.

(*d*) *In Deane, and Adams'* Pistols, the Barrel and Stock being in one, the *Weight of the Barrel alone* cannot be given. These Pistols, as well as Colt's, *and the Cavalry 8-inch* Pistol, have no back sights.

OF ARMS, AND AMMUNITION—*continued.*

Loaders.

Barrel.			Ammunition, &c.								
Grooves.			Bullet.								
Description.	Degree of Spirality.	Arms sighted up to	Description.	Weight.	Diameter.	Length.	Windage. (e)	Charge of Powder.		Weight of Sixty Rounds and Seventy-five Copper Caps Packed.	
		yds.		gr.	in.	in.	in.	dr.	gr.	lbs.	oz.
Progressive.	1 in 48	600	Plug.	530	·55	$1\frac{1}{10}$	·027	2	0	5	$7\frac{1}{2}$
Do.	1 in 48	600	Do.	530	·55	$1\frac{1}{10}$	·027	2	0	5	$7\frac{1}{2}$
Do.	Variable	1000	Do.	530	·55	$1\frac{1}{10}$	·027	$2\frac{1}{2}$	0	5	$10\frac{1}{4}$
Do.	1 in 48	1250	Do.	530	·55	$1\frac{1}{10}$	·027	$2\frac{1}{2}$	0	5	$10\frac{1}{4}$
Do.	1 in 78	1000	Do.	530	·55	$1\frac{1}{10}$	·027	$2\frac{1}{2}$	0	5	$10\frac{1}{4}$
Do.	1 in 78	1100	Do.	530	·55	$1\frac{1}{10}$	·027	$2\frac{1}{2}$	0	5	$10\frac{1}{4}$
Do.	1 in 48	1250	Do.	530	·55	$1\frac{1}{10}$	·027	$2\frac{1}{2}$	0	5	$10\frac{1}{4}$
Uniform.	1 in 20	{1250}	Cylindrcl.	480	·442	$1\frac{29}{100}$	·009	0	75	5	$9\frac{1}{2}$
Do.	1 in 20	{1350}	Hexagonal	530	·469† ·438	$1\frac{47}{100}$	·012	0	85	6	$3\frac{1}{4}$
Do.	1 in 20	800	Plain.	402	·467	$1\frac{4}{100}$	*	2	0	4	$7\frac{1}{2}$
Do.	1 in 48	600	Do.	545	·568	$1\frac{9}{100}$	*	0	62	6	2
Do.	1 in 36	500	Pritchett.	530	·568	·99	*	2	0	5	5
Progressive.	1 in 48	(d) 100	Hollow.	390	·568	$\frac{11}{20}$	·009	1	0	3	$15\frac{3}{4}$
Do.	1 in 48	300	Do.	390	·568	$\frac{11}{20}$	·009	1	0	3	$15\frac{3}{4}$
Uniform.	1 in 20	No (d) Sight.	Plain.	191	·450	$\frac{11}{20}$	*	0	15	1	15
Progressive.	1 in 36	Do. (d)	Do.	131	·383	$\frac{63}{100}$	*	0	11	1	$6\frac{3}{4}$
Uniform.	1 in 18	Do. (d)	Do.	245	·490	·66	*	0	20	2	$7\frac{1}{4}$
..	..	Do. (d)	Spherical.	203	·515	..	·055	2	0	..	

(*e*) The Windage is estimated by taking the difference between the Diameter of the Bullet and the Diameter of the Bore. No Allowance is made for the paper round the Bullet, which measures ·009 of an inch.

(*f*) In the Revolvers the Gauge is measured by the number of Spherical Bullets to the Pound.

* In the Breech-loaders, and Revolvers, the Diameter of the Bullet being greater than that of the *Bore, there is, of course,* no Windage.

† *Whitworth's Hexagonal Bullet* measures ·469 across angles and ·438 *across flats.*

WEIGHT, AND DIMENSIONS OF BREECH-LOADING ARMS, ON SNIDER'S SYSTEM.

Description of Arm.	Musket. Weight. With (Bayonet, or Sword Bayonet.)	Musket. Weight. Without (Bayonet, or Sword Bayonet.)	Musket. Length. With (Bayonet, or Sword Bayonet.)	Musket. Length. Without (Bayonet, or Sword Bayonet.)	Bayonet, or Sword. Weight.	Bayonet, or Sword. Length beyond Muzzle.	Bayonet, or Sword. Weight of Scabbard.	Barrel. Dimensions, &c. Weight.	Barrel. Dimensions, &c. Length.	Barrel. Dimensions, &c. Diameter of Bore.	Barrel. Grooves. Number.	Barrel. Grooves. Width.	Barrel. Grooves. Depth. Muzzle.	Barrel. Grooves. Depth. Breech.	Barrel. Grooves. Description.	Barrel. Grooves. Degree of Spirality.	Arms Sighted up to
	lbs. oz.	lbs. oz.	ft. in.	ft. in.	lbs. oz.	ft. in.	ozs.	lbs. oz.	ft. in.	in.		in.					yds.
Rifle, Enfield, Long Pattern, 1853, for Infantry.	9 12¼	8 15	5 11¼	4 6	0 13¼	1 5½	4½	4 10¼	3 3	·577	3	·235	·055	·013	Progressive	1 in 78	950
Rifle, Enfield, Short Pattern, 1860, for R. V. Corps, and Serjeants of Infantry Regiments.	10 7¼	8 12	5 11¼	4 0¼	1 11½	1 10¾	7½	4 8¼	2 9	·577	5	·235	·005	·013	Do.	1 in 48	1000
Rifle, Pattern 1858, for Royal Navy.	11 2	8 12	6 3⅜	4 0¼	2 6	2 2⅞	10¼	4 8¼	2 9	·577	5	·235	·005	·013	Do.	1 in 48	1000
Carbine, Rifled, Enfield Pattern 1861, for Cavalry.	..	6 11	..	3 0¾	..	..	..	2 9¾	1 9	·577	5	·235	·005	·013	Do.	1 in 48	600
Carbine, Rifled, Enfield Pattern 1861, for Artillery.	9 4	7 8	5 3	3 4¼	1 12	1 10¾	12	3 0	2 0	·577	5	·235	·005	·013	Do.	1 in 48	600
Carbine, Lancaster's Patent, Oval Bore, for Royal Engineers.	9 12¼	8 2	5 11¼	3 11¼	1 10¼	2 0	9¾	4 2¼	2 7¼	·577	..	Oval Bore.			Do.	Variable.	1150

RIFLE EXERCISES.*

RIFLES when unloaded are to be carried with the hammer down on the nipple; when loaded, they are to be carried at half-cock.

MANUAL EXERCISES.

PART III.—*S.* 1. *Manual Exercise with the Long Rifle.*

1. *By Numbers.*

1. *From the Order Arms.*
2. Fix—bayonets.
3. Shoulder—arms—Two.
4. Present—arms—Two—Three.
5. Shoulder—arms—Two.
6. Port—arms—Two.
7. As a Front rank, Charge bayonets; As a Rear rank, Charge bayonets.
8. Shoulder—arms—Two.
9. Advance — arms — Two — Three.
10. Order—arms—Two—Three.
11. Advance—arms—Two.
12. Shoulder — arms— Two — Three.
13. Support — arms — Two — Three.
14. Shoulder — arms — Two — Three.
15. Slope—arms.
16. Shoulder—arms.
17. Order—arms—Two—Three.
18. Unfix—bayonets.
19. Slope—arms—Two.
20. Order—arms—Two—Three.
21. Trail—arms.
22. Order—arms.
23. Advance—arms—Two.
24. Trail—arms—Two.
25. Advance—arms—Two.
26. Order—arms—Two—Three.
27. Ground—arms.
28. Take up—arms.
29. The short trail.
30. Stand at ease.

S. 2. *The Manual Exercise with the Short Rifle.*

1. *By Numbers.*

1. *From the Order.*
2. Shoulder—arms—Two.
3. Present—arms—Two—Three.
4. Shoulder—arms—Two.
5. Support—arms.
6. Shoulder—arms.
7. Order—arms—Two.
8. Fix—swords.
9. Shoulder—arms—Two.
10. Port—arms—Two.
11. As a Front rank, Charge—swords; As a Rear rank, Charge—swords.

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* *From "Field Exercise,* and Evolutions of Infantry."

FUNERALS.

PART VII.—*S.* 20. *Directions for Funeral parties.*

The escort will be drawn up two deep, with opened ranks and unfixed bayonets, facing the house, or marquee, where the corpse is lodged. When the corpse is brought out, the officer commanding will proceed as follows:—

PRESENT ARMS—REVERSE ARMS—REAR RANK TAKE CLOSE ORDER, MARCH—BY COMPANIES (SUB-DIVISIONS, OR SECTIONS), LEFT WHEEL (OR, ON THE RIGHT BACKWARDS WHEEL)—QUICK MARCH—HALT—DRESS—REAR RANK TAKE OPEN ORDER—MARCH—TO THE LEFT—FACE—SLOW—MARCH.

The remainder of the procession will be thus formed:—

THE CORPSE.

Pall-bearers on each side of the corpse.
Chief mourners.
Officers, or Non-commissioned officers, two and two, according to rank, the juniors in front.

When the head of the procession arrives near the spot where it is to meet the Clergyman—

COMPANIES (OR SUB-DIVISIONS) TO THE LEFT TURN, RIGHT WHEEL—HALT—RANKS INWARDS FACE—FRONT RANK FOUR PACES STEP BACK—SLOW MARCH—REST UPON YOUR ARMS REVERSED—STAND AT EASE.

The Corpse having passed through—

ATTENTION—REVERSE ARMS—RANKS, RIGHT AND LEFT FACE—SLOW MARCH—HALT—FRONT, *when near the grave and facing towards it*—REST ON YOUR ARMS REVERSED—STAND AT EASE.

The Funeral service will be performed, after which—

ATTENTION—PRESENT ARMS—SHOULDER ARMS—WITH BLANK CARTRIDGE, LOAD—FIRE THREE VOLLEYS IN THE AIR—READY—PRESENT.

After firing Three rounds the men will be directed to "Order arms—Fix bayonets—Shoulder arms," and the ranks will be closed. The escort will then be marched back to camp, or barracks, in fours, sub-*divisions, or* sections, right in front, in quick time.

SWORD EXERCISE.

SECTION II.—CUTS. GUARDS. POINTS.

Words of Command.

Engage.	Right—Defend.
Assault.	Second.
One, Two, Three, Four — Right.	Third.
One, Two, Three, Four — Left.	Fourth.
	Left—Defend.
	Second.
	Third.
	Fourth.

Slope swords.

GUARDS, AND POINTS.

Words of command.

Guards, and Points.	
Right—Defend.	Point.
Second.	Point.
Third.	Point.
Fourth.	Point.
Left—Defend.	Point.
Second.	Point.
Third.	Point.
Fourth.	Point.

Slope swords.

SWORD EXERCISE.

Words of command.

Right engage.	Left engage.
Assault.	Assault.
One —Point.	One —Point.
Two —Point.	Two —Point.
Three—Point.	Three—Point.
Four —Point.	Four —Point.

Slope swords.

PURSUING PRACTICE.

Words of command.

Pursuing practice.	
Assault.	
One. —Point.	Right.
One —*Point.*	Left.
Three—Point.	Right.
Three—Point.	Left.

PISTOL EXERCISE.

Words of command.

Draw pistol. Prepare to load. Load. Rod. Home. Return. Cap. Ready. To the Front. Present. Fire. Load. Ready. To the Left. Present. Load. To the Right. Present. Fire. Load. To the Rear. Present. Fire. Return pistol.

LANCE EXERCISE.

Words of command.

Engage.

Round.	Wave, and
	First point.
Right front.	Second point and Thrust.
	Parry.
Right rear.	Third point.
Left rear.	Fourth point.
	Thrust.
Left front.	Fourth point.
	Carry lance.

FIRST DIVISION.

AGAINST CAVALRY.

Words of command.

Engage.

Right front.	Wave, Second point, and Thrust.
Left front.	Wave, Fourth point, and Thrust.
Right rear.	Third point.
Left rear.	Fourth point.
	Carry lance.

SECOND DIVISION.

AGAINST INFANTRY.

Words of command.

Engage.

Right front.	First point, and Thrust.
Left front.	First point, and Thrust.
Right rear.	Third point.
Left rear.	Fourth point.
	Carry lance.

PART II.

FIELD EXERCISE, AND EVOLUTIONS OF INFANTRY.*

MARCHING.

PART I.—*S.* 7. *Length of Step.*

In slow, or quick time the length of a pace is 30 inches, except in "stepping out," when it is 33 inches, and in "stepping short" 10.

In "double time" the length of the pace is 36 inches.

The length of the side step, which is always taken in quick time, is 10 inches.

N.B. When a soldier takes a side pace to clear, or cover another, as in forming four deep, the pace will be 24 inches.

In stepping back the pace is 30 inches.

S. 8. *Cadence.*

In slow time	75 steps	62 yards	18 inches	are taken
In quick time	110 ,,	91 ,,	24 ,,	in a
In double time	150 ,,	150 ,,	— ,,	minute.

S. 39. *Taking Open order.* 1. *From the Halt.*

† Rear rank, take open order, March—Rear rank, dress—Eyes front—Rear rank, take close order, March.

2. *On the March.*

† Rear rank take open order—Rear rank take close order.

S. 47. *Breaking off Files.*

† Three files on the left, to the right turn—Left-wheel.

The front of the Squad may be further reduced by any number of files; suppose Two:

† Two files on the left, to the right turn—Left-wheel.

Any number of Files that have been broken off may be again ordered to the front; suppose Three:

† Three files to the front—Two files to the front.

All the Files may be brought to the front at once by the Words—

† Files to the front.

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* *Note* 1. In consequence of the limited size of this Manual, extracts only have been taken from "THE FIELD EXERCISE, AND EVOLUTIONS OF INFANTRY," the matter selected being that generally required in the field.

The PARTS, and SECTIONS are numbered in conformity with the authorized publication.

Note 2. *Words of Command, and Directions:—*

The Commander's Words *are printed in* . . . SMALL CAPITALS.
The *Executive words, &c.* . . . . † Small Print.
The Directions, &c. . . . . *Italics.*

PART II.—GENERAL PRINCIPLES.

VII. *Relative Proportion of Paces to Files.*

Each man occupies a space of about 24 inches; therefore, to ascertain the number of paces of 30 inches required for a given number of files, multiply the number of files by 8, and divide by 10, the latter operation being accomplished by cutting off the last figure, which multiplied by 3 will designate the odd inches. It will be useful to remember, that 10 files require 8 paces, 20 files 16, and so on—100 files 80 paces, 1,000 files 800.

A COMPANY IN LINE, AND COLUMN.

S. 1. *Formation of a Company in Line.*

Caution—AS A COMPANY IN LINE.

1. *Formation in Close order.*—On the above caution, the captain will place himself on the right of the front rank, covered by his covering serjeant, who will be on the right of the rear rank; the remaining officers and serjeants will place themselves in a third or supernumerary rank, three paces from the rear rank; the lieutenant in rear of the second file from the left, the ensign in rear of the centre of the company, the third supernumerary in rear of the left subdivision, the fourth in rear of the right, the fifth in rear of the left, and so on.

2. *Taking open order.*

* REAR RANK TAKE OPEN ORDER—MARCH.	* Rear rank, dress—Eyes front. Supernumerary rank, dress—Eyes front.
STEADY.	*On the word* STEADY, *the Officers will port their swords.*

3. *Resuming Close order.*

REAR RANK TAKE CLOSE ORDER—MARCH.

WHEELING FROM THE HALT.

S: 4. *A Company wheeling, from the Halt, from Column into Line.*

Caution.—AS A COMPANY IN COLUMN, RIGHT IN FRONT.

LEFT WHEEL INTO LINE — QUICK MARCH.	Company—Halt. Dress. Eyes front.

A Company in Column, Left in front, will be taught to wheel into Line in a similar manner, on the Commands—

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* *Vide Note* *, *page* 15.

RIGHT WHEEL INTO LINE, &c.

S. 5. A Company wheeling from the Halt, from Line into Column.

Caution.—AS A COMPANY IN LINE.

OPEN COLUMN, RIGHT IN FRONT. RIGHT ABOUT FACE. RIGHT WHEEL, QUICK MARCH.	Company, Halt—Front—Dress.

A Company in Line will also be taught to wheel into an Open Column, Left in front, in like manner; the Company, having been faced about, will wheel to the left.

S. 6. A Company wheeling any given number of paces, on either flank, from the Halt.

—— PACES, RIGHT (OR LEFT) WHEEL; OR —— PACES ON THE RIGHT (OR LEFT) BACKWARD WHEEL. QUICK MARCH.	Halt—Dress. Eyes front.

The eighth File wheeling eight paces will complete the quarter circle, four paces the eighth of a circle, and two paces the sixteenth of a circle.

S. 7. A Company wheeling on the Centre, from the Halt.

ON THE CENTRE, RIGHT (OR LEFT). OR ON THE CENTRE—— PACES TO THE RIGHT (OR LEFT) WHEEL. QUICK MARCH.—STEADY.	Company, Halt — Dress— Eyes front.

S. 8. Wheeling backward by Sub-divisions, or Sections from Line.

1. *Wheeling back on the Left.*

BY SUB-DIVISIONS (OR SECTIONS) ON THE LEFT BACKWARDS WHEEL. QUICK MARCH.	Halt—Dress.

2. *Wheeling back on the Right.* In like manner Sub-divisions, or Sections, will wheel backwards on the right.

S. 9. On Open column of Sub-divisions, or Sections, Wheeling into Line.

1. *A Column, right in front, wheeling to the left, into Line.*

LEFT WHEEL INTO LINE. QUICK MARCH. | Halt—Dress. Eyes front.

2. *A Column, left in front, wheeling to the right, into Line.*
In like manner a Company in column of sub-divisions, or sections, left in front, will wheel into Line.

WHEELING ON A MOVEABLE PIVOT.

S. 10. Wheeling from Column into Line, and from Line into Column.

1. *From Column into Line.*

RIGHT (OR LEFT) WHEEL INTO LINE. FORWARD.	*While on the March.*

2. *From Line into Column.*

BY COMPANIES (SUB-DIVISIONS, OR SECTIONS) RIGHT (OR LEFT) WHEEL. FORWARD.	*While on the March.*
ON THE MOVE, BY COMPANIES, SUB-DIVISIONS, &c. FORWARD.	*From the Halt.*

S. 11. *Columns changing direction.*

CHANGE DIRECTION TO THE RIGHT (OR LEFT). FORWARD.	*Each company, &c., will wheel in succession.* Forward.

S. 12. *A Company in Line advancing from a flank in open Column of Sub-divisions, or Sections.*

1. *By Sub-divisions from the Right.*

RIGHT SUB-DIVISION TO THE FRONT; REMAINING SUB-DIVISIONS, ON THE MOVE, RIGHT WHEEL—QUICK MARCH. FORWARD.	Left wheel. Forward. Forward.

2. *By Sub-divisions from the Left, or Sections from either flank.*

A Company will advance by Sub-divisions from the Left in like manner, or by Sections from either flank, the rear Sections changing direction.

MISCELLANEOUS MOVEMENTS, AND FORMATIONS.

S. 13. *Marching past in Slow, and Quick time.*

SLOPE ARMS. MARCH PAST IN SLOW TIME, SLOW, MARCH. COMPANY—HALT.	Left wheel. Forward. Left wheel. Forward, by the right. Rear Rank take open order. Rear Rank take close order. Left wheel. Forward, by the left. Left wheel. Forward.
MARCH PAST IN QUICK TIME. QUICK MARCH.	Left wheel. Forward. Left wheel. Forward. By the right. Left wheel. Forward. By the left. Left wheel. Forward.

COMPANY—HALT.

S. 14. *The Echellon march of Sub-divisions, or Sections.*

TAKE GROUND TO THE RIGHT (OR LEFT), IN ECHELLON. ON THE MOVE, BY SUB-DIVISIONS (OR SECTIONS) RIGHT (OR LEFT) WHEEL. QUICK MARCH.—FORWARD.

A Company on the march will take ground to a flank in echellon in the same manner, the command being "BY SUB-DIVISIONS (OR *SECTIONS*), *RIGHT* (OR *LEFT*) WHEEL, FORWARD.—RE-FORM COMPANY. *FORWARD.*"

* *S.* 16. *A Company, in Column of Sub-divisions (or Sections), rming to the reverse flank.*

A Company in Column of sub-divisions, right in front, will form to e Right, as follows:—

IGHT FORM COMPANY.	Leading Sub-division, right wheel. Double. Forward. Halt—Dress up. By the Right.
TEADY.	Left Sub-division, right wheel. Double. Forward. Halt—Dress up. Eyes front.

A Column of Sub-divisions Left in front will form Company to the eft in like manner. A Column of Sections will form Company to the everse flank on similar principles.

* *S.* 23. *Counter-marching.*

A Company in Column, right, or left in front.

By Ranks.

OUNTERMARCH BY RANKS. RIGHT AND LEFT FACE. QUICK MARCH.	Company—Halt —Front—Dress.

INCREASING, AND DIMINISHING THE FRONT OF COLUMNS.

S. 24. *A Company diminishing Front, by forming Sub-divisions rom the Halt.*

AS A COMPANY IN COLUMN, RIGHT (OR LEFT), IN FRONT.

Right in front.

ORM SUB-DIVISIONS. LEFT SUB-DIVISION, RIGHT ABOUT THREE-QUARTERS FACE. QUICK MARCH.	Halt—Front—Dress.

If Left is in front, Sub-divisions will be formed in a similar nanner, the Right sub-division moving to the rear of the Left.

S. 25. *A Company diminishing Front by forming Sub-divisions on he march.*

AS A COMPANY IN COLUMN, RIGHT (OR LEFT), IN FRONT.

Right in front.

ORM SUB-DIVISIONS.	Left sub-division—Mark time. Right half turn. Front turn.

If Left is in front, Sub-divisions will be formed in a similar nanner, the Right sub-division moving to the rear of the Left.

S. 26. *Sub-divisions diminishing Front, by forming Sections.*

The directions that apply to the formation of Sub-divisions from a Company, apply equally to the formation of Sections from Sub-divisions: if the Company is halted, the Drill instructor will give the

* *In consequence of the limited size of* this Manual, the Sections, which *r chiefly directions, are necessarily omitted.*

words — LEFT (OR RIGHT) SECTIONS, RIGHT (OR LEFT) ABOUT THREE-QUARTERS FACE, QUICK MARCH; but, if on the march, the Captain will give the words—"Left (or Right) Sections, Mark time; Right (or Left) half turn" to both Sections. The Section leaders giving the words "Halt—Front—Dress," or "Front turn."

S. 27. Sections increasing Front by forming Sub-divisions from the Halt.

FORM SUB-DIVISIONS. LEFT SECTION, LEFT HALF FACE. QUICK MARCH.	Halt — Front, Dress.

S. 28. Sections increasing Front by forming Sub-divisions on the March.

Right in front.

FORM SUB-DIVISIONS.	Left Sections, Left half turn, Double, Front turn, Quick.

A Column of Sections, left in front, will form Sub-divisions in like manner, both from the halt, and on the march.

S. 29. Sub-divisions increasing Front by forming Company.

The directions that apply to the formation of Sub-divisions from Sections, apply equally to the formation of a Company from Sub-divisions.

S. 30. Diminishing, and increasing Front by breaking off Files, and bringing them again to the Front.

Files will be broken off, as described in Sec. 47, PART I.

BREAK OFF FILES.

S. 31. Increasing, and diminishing Front by breaking into Fours, or Files, and re-forming Sections, Sub-divisions, or Company.

A Company, or open Column of Sub-divisions, or Sections, right in front, may advance from the right in Files, or Fours, by the words—TO THE RIGHT FACE (or FORM FOURS RIGHT) LEFT WHEEL, QUICK MARCH; if the Column is Left in front, the fours, or files will advance from the Left in like manner. These movements may also be done when the Column is on the march, the commands then being—TO THE RIGHT (OR LEFT) TURN, LEFT (OR RIGHT) WHEEL: OR FORM FOURS, RIGHT—LEFT WHEEL: OR FORM FOURS, LEFT—RIGHT WHEEL.

SQUARES.

S. 32. Forming close Column of Sections, and Company square.

FORM COMPANY SQUARE.	Form close Column of Sections. Quick march. Prepare for Cavalry. Ready. Independent firing, &c., &c. Order arms.

The Company will be re-formed, as follows:—

RE-FORM COMPANY.	Re-form company. Quick march.

S. 33. *Forming Rallying Squares.*

FORM RALLYING SQUARE.

THE SQUARE WILL ADVANCE (RETIRE, OR MOVE TO THE RIGHT, OR LEFT). QUICK MARCH.	The Square will advance (retire, or move to the right or left). Inwards—Face—Quick march.
THE SQUARE WILL HALT.	Halt. Prepare for Cavalry — Ready. Order arms.
RE-FORM COMPANY.	Unfix Swords (or bayonets). Re-form Company.

PART IV.—FIELD EXERCISE, AND EVOLUTIONS OF INFANTRY.

FORMATION, AND EVOLUTIONS OF A BATTALION.

A BATTALION ON PARADE.

S. 1. *Formation of a Battalion on Parade in Open Column, Right in front.*

As a general rule, a battalion will assemble on parade in open column right in front.

The usual post of the commanding officer in open column is on the pivot flank of the leading company; that of the senior major, two paces from the reverse flank of the centre of the right wing, and that of the second major, two paces from the reverse flank of the centre of the left wing. The adjutant is posted two paces from the reverse flank of the right centre company. When a column is ordered to advance, the major of the leading wing will place himself in rear of the pivot flank of the second company from the front, to superintend the direction, keeping clear of the Company leaders.*

TELL OFF THE BATTALION. NOS. ONE TO FIVE, RIGHT WING. NOS. SIX TO TEN, LEFT WING. EYES FRONT.	No. One. No. Two. &c. &c. &c.

S. 2. *Wheeling into Line from Open Column.*

LEFT (OR RIGHT) WHEEL INTO LINE. QUICK MARCH.	Steady. No. ——, Halt. Dress. Eyes front.

FORMATION, AND MOVEMENTS OF A BATTALION IN LINE.

S. 3. *Formation of a Battalion in Line.*

When a Battalion is formed in Line there is to be no interval between the Companies.

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* *Vide Note* 2, *page* 19.

S. 4. *A Battalion in Line taking Open order, and resuming Close order.*

1. *Taking Open order.*

REAR RANK TAKE OPEN ORDER. MARCH.	Steady.

2. *Taking Close order.*

REAR RANK TAKE CLOSE ORDER. MARCH.	

S. 5. *Advancing, and retiring in Line.*

1. *Advancing in Line.*

THE LINE WILL ADVANCE.* QUICK MARCH. BATTALION HALT.	* Steady.

2. *Retiring in Line.*

THE LINE WILL RETIRE. RIGHT ABOUT FACE. QUICK MARCH. BATTALION HALT—FRONT.	Steady.

S. 6. *Charging in Line.*

PREPARE TO CHARGE. CHARGE. BATTALION HALT.	

S. 7. *Dressing a Battalion in Line.*

THE BATTALION WILL DRESS BY THE RIGHT (OR LEFT). COVERERS—— PACES TO THE FRONT. QUICK MARCH.* QUICK MARCH.	* Steady. Halt. Dress up. No. ——, Eyes front. * Steady.

S. 8. *Advancing, and Retiring by Wings.*

1. *Firing, and Advancing by Wings.*

THE BATTALION WILL FIRE AND ADVANCE BY WINGS.	*Junior Major.* Left wing—Fire a volley at —— yards—Ready, Present. Load. *Senior Major.* Right wing, By the left. Quick march. Right wing—Halt, &c. *Junior Major.* Left wing, Shoulder arms. By the right. Quick march, &c. *Senior Major.* Right wing—Fire a volley at —— yards—Ready, Present. Load, &c.

2. *Firing, and Retiring by Wings.*

THE BATTALION WILL FIRE AND RETIRE BY WINGS.	*Junior Major.* Left wing—Fire a volley at —— yards—Ready, Present. Load. Shoulder arms. Right about face. By the left—Quick march. Halt—Front. *Senior Major.* Right wing—Fire a volley at —— yards—Ready, Present. Load. Shoulder arms. Right about face. By the right—Quick march. Halt—Front. *Junior Major.* Left wing, Ready, &c.

S. 9. A Battalion in Line passing obstacles.

If the obstacles are small, the files whose progress is interrupted by them, will break off in the same manner as files are broken off from the flank of a Company in column. The moment the obstacle is passed, the files must move up again to the front. If a Company or Sub-division is required to break off, it will move by Fours, or if Files break off successively till they amount to a Sub-division, they will form Fours.

ADVANCE BY FOURS FROM THE RIGHT (OR LEFT) OF COMPANIES. FORM FOURS—RIGHT, LEFT WHEEL; OR FORM FOURS—LEFT, RIGHT WHEEL.	*When the obstacles are such as to require all the Companies to break into Fours.*
RETIRE BY FOURS FROM THE PROPER RIGHT (OR LEFT) OF COMPANIES. FORM FOURS—LEFT, RIGHT WHEEL; OR FORM FOURS—RIGHT, LEFT WHEEL.	*If all the Companies of a Battalion retiring in Line are required to break into Fours.*

S. 10. Battalions in Line relieving each other.

1. *Advancing.*

RETIRE BY FOURS FROM THE RIGHT OF COMPANIES. FORM FOURS—RIGHT. RIGHT WHEEL. QUICK MARCH.	
HALT—FRONT. LEFT WHEEL INTO LINE. QUICK MARCH.	Halt, Dress.

2. *Retiring.*

RETIRE BY FOURS FROM THE PROPER RIGHT OF COMPANIES. FORM FOURS—LEFT, &c.	

COLUMN MOVEMENTS.

S. 11. Formation of a Battalion in Open column.

The rules laid down for the formation of an open Column, Right in front (in this PART, Section 1), are equally applicable to the formation of an Open column Left in front.

S. 12. Forming Close, or Quarter distance column from any more Open column.

1. *Closing from the Halt.*

CLOSE TO THE FRONT (OR TO QUARTER DISTANCE ON THE FRONT COMPANY): OR CLOSE TO THE REAR (OR TO QUARTER DISTANCE ON THE REAR COMPANY).	* No.—— Halt—Dress.
REMAINING COMPANIES RIGHT ABOUT FACE; OR CLOSE ON (OR TO QUARTER DISTANCE ON) NO. —— COMPANY. COMPANIES IN FRONT, RIGHT ABOUT FACE. QUICK MARCH.*	No. —— Halt—Front —Dress. Steady.

2. *Formation of a Close, or Quarter distance Column.*

The arrangement of a Close, or Quarter distance column will be the same as that of an open column, the distances only being different.

3. *A Column on the march, closing to the Front.*

CLOSE TO THE FRONT (OR CLOSE TO QUARTER DISTANCE, ON THE LEADING COMPANY).	Captain of the leading Company, "No. 1. Halt—Dress." The column will then be formed as already described.

4. *Closing to the Front without Halting.*

ON THE MARCH—CLOSE TO THE FRONT (OR CLOSE TO QUARTER DISTANCE) ON THE LEADING COMPANY. REMAINING COMPANIES, DOUBLE.	No. —— Quick.

S. 13. *A Close, or Quarter distance column opening from the Front, Rear, or from any named Company.*

1. *From the Front.*

OPEN TO QUARTER (OR WHEELING) DISTANCE FROM THE FRONT. REMAINING COMPANIES, RIGHT ABOUT FACE. QUICK MARCH.	No. —— Halt —Front—Dress.

2. *Opening from the Rear.*

OPEN TO QUARTER (OR WHEELING) DISTANCE FROM THE REAR. REMAINING COMPANIES, QUICK MARCH.	No. —— Halt. No. —— Dress.

3. *Opening from a Central Company.*

The Companies, in front and rear of the central company, will proceed as already described.

4. *Advancing in Succession from the Front.*

ADVANCE BY SUCCESSIVE COMPANIES FROM THE FRONT, AT QUARTER (OR WHEELING) DISTANCE. NO. —— QUICK MARCH.	*In Succession,* No. —— Quick march.

5. *Opening on the March, by Halting the Rear Company.*

OPEN TO QUARTER (OR WHEELING) DISTANCE, FROM THE REAR.	*Rear Company* Halt. *Movement as described from the Halt.*

S. 14. *Columns increasing, and diminishing their Front, and passing obstacles.*

When an open Column is on the march, each Company in succession, as it arrives at a narrow space or defile, will, when necessary, *diminish its front;* and, as each Company clears the narrow space, it *must again increase its* front.

S. 15. *An Open Column changing direction, and marching on an alignment, or moving into an alignment by the Flank march of Fours.*

1. *Changing direction.*

A Battalion marching in Column may change direction by the successive wheel of its Companies on moveable pivots round the same point.

S. 16. *A Column at Close, or Quarter distance, Wheeling on a fixed, or moveable pivot.*

1. *Wheeling on a Fixed pivot.*

COLUMN—LEFT (OR RIGHT) WHEEL. QUICK (OR DOUBLE) MARCH. COLUMN—HALT.

2. *Wheeling on a Moveable pivot.*

COLUMN LEFT (OR RIGHT) WHEEL. COLUMN—FORWARD.

S. 17. *A Close, or Quarter distance Column taking ground to a flank, wheeling to the right, or left.*

A Column taking ground to a flank will wheel to the right, or left, on the principles laid down in the preceding Section.

S. 18. *A Close, or Quarter distance Column changing Front on the Centre.*

1. *From the Halt.*

CHANGE FRONT ON THE CENTRE. RIGHT (OR LEFT) SUB-DIVISIONS, RIGHT ABOUT FACE. QUICK (OR DOUBLE) MARCH. HALT—FRONT, DRESS.

2. *On the March.*

CHANGE FRONT ON THE CENTRE. RIGHT (OR LEFT) SUB-DIVISIONS—RIGHT ABOUT TURN. FRONT TURN.

S. 19. *Columns countermarching by Ranks.*

In countermarching, both the front of the Column and the order of the Companies is changed, a column Right in front becoming a column Left in front, facing to the original rear.

S. 20. *Changing the Order of a Column, by the successive march of the rear Companies to the front.*

When Right in Front.

BY SUCCESSIVE COMPANIES, REAR WING TO THE FRONT.	*Captain of rear company.* No. —— Form Fours left. Quick march. Front—turn. By the right. *Captain of next company.* No. —— Form Fours left. Quick march. Front—turn. By the right.

The remaining Companies will successively follow in a similar manner.

When Left is in front, the Right companies will be brought to the front in a similar manner, each forming fours to the right, and coming up in succession.

S. 21. *Changing the Order of an Open, Half, or Quarter distance column, formed upon a road where the space does not admit of the flank movement.*

When Right in Front.

BY FOURS FROM THE LEFT, REAR WING TO THE FRONT.	*Captain of rear company.* No. —— Form Fours—left. Right wheel.
FOURTH SECTIONS RIGHT WHEEL.	Fourth section, Halt. *Captain of next company.*
QUICK MARCH.	No. —— Form Fours—left. Quick march. *Captain of left company.* No. —— Front—form company.—Forward.

The remaining companies will follow in like manner. A column *Left in front* will bring its rear companies to the front by fours from the Right in a similar manner; the first sections being wheeled to the left.

S. 22. *Columns taking ground to a flank, by the Echellon march of Sections.*

When a Column is required to take ground to a flank in echellon of sections, each Company will move, as described in PART II., Section 14.

S. 23. *Columns taking ground to a Flank.*

TAKE GROUND TO THE RIGHT (OR LEFT) IN FOURS. FORM FOURS—RIGHT (OR LEFT). (QUICK MARCH, *if halted.*)

S. 24. *Columns, when taking ground to a flank by Fours, closing to less distance, or opening out to greater distance from any named Company.*

1. *Closing to less distance.*

CLOSE ON NO. —— COMPANY (OR CLOSE TO QUARTER DISTANCE ON NO. —— COMPANY). * COLUMN FORWARD.	* *When the movement is completed.*

2. *Opening to greater distance.*

OPEN TO QUARTER (OR WHEELING) DISTANCE FROM NO. —— COMPANY. * COLUMN—FORWARD.	* *When the movement is completed.*

On open ground the Companies in these movements may close, or *open by the diagonal march.*

BY THE DIAGONAL MARCH, CLOSE (OR OPEN OUT), &c. REMAINING COMPANIES—INWARDS (OR OUTWARDS) HALF TURN.	No. —— Right half turn. No. —— Left half turn.

S. 25. *Application of the Flank march of Columns by Fours.*

The flank march of Columns by Fours will be found most useful in the advance of large bodies of troops.

FORMATIONS OF COLUMN, FROM LINE.

S. 26. *A Line wheeling back into Open column from the Halt.*

1. *By Companies into Open column, Right in front.*

OPEN COLUMN, RIGHT IN FRONT—RIGHT ABOUT FACE. RIGHT WHEEL. QUICK MARCH.	Halt—Front—Dress.

2. *By Companies into Open column, Left in front.*

Open column, left in front, will be formed in like manner.

3. *By Sub-divisions (or Sections) into Column, Right in front.*

BY SUB-DIVISIONS (OR SECTIONS) ON THE LEFT BACKWARD—WHEEL. QUICK MARCH.	Halt—Dress.

4. *By Sub-divisions (or Sections) into Column, Left in front.*

Sub-divisions and Sections will wheel back on their right in like manner.

When the Sub-divisions, or Sections, exceed twelve Files, the words of command will then be—

OPEN COLUMN OF SUB-DIVISIONS (OR SECTIONS) RIGHT (OR LEFT) IN FRONT, RIGHT ABOUT—FACE, &c., &c.

S. 27. *A Line wheeling into Open column on the march.*

BY COMPANIES (SUB-DIVISIONS, OR SECTIONS) RIGHT (OR LEFT) WHEEL. FORWARD.

When a Battalion is required to wheel on moveable pivots from the Halt, the caution must be given thus—

ON THE MOVE BY COMPANIES (SUB-DIVISIONS, OR SECTIONS) RIGHT (OR LEFT) WHEEL, QUICK MARCH.

S. 28. *A Battalion moving in Open column, from either flank, along the Rear.*

1. *By Companies from the Right.*

THE BATTALION WILL MOVE IN COLUMN OF COMPANIES, FROM THE RIGHT, ALONG *THE REAR.*	No. 1. Form Fours—Left. Left wheel. Quick march. Front turn. No. 2. Form Fours—Left. Left wheel. Quick march. Front turn. *Companies in succession.*

2. *By Companies from the Left.*

MOVE IN COLUMN OF COMPANIES, FROM THE LEFT, ALONG THE REAR.	No. —— Form Fours — Right. Right wheel. Quick march. Front turn. *Companies in succession.*

S. 29. *A Battalion formed in Line, advancing from a flank, in Open column of Companies, Sub-divisions, or Sections.*

1. *Advancing from a Flank, by Companies.*

RIGHT (OR LEFT) COMPANY TO THE FRONT. REMAINING COMPANIES ON THE MOVE, RIGHT (OR LEFT) WHEEL. QUICK MARCH. FORWARD.	No. ——* Left (or right) wheel. Leading Company—Forward. No. ——* Forward. &c., &c., &c.

2. *Advancing from a Flank by Sub-divisions, or Sections.*

RIGHT (OR LEFT) SUB-DIVISION (OR SECTION) TO THE FRONT, REMAINING SUB-DIVISIONS (OR SECTIONS), ON THE MOVE, RIGHT (OR LEFT) WHEEL. QUICK MARCH. FORWARD, &c., &c.

3. *Advancing from a Flank by Companies, Sub-divisions, or Sections, on the March.*

RIGHT (OR LEFT) COMPANY (SUB-DIVISION, OR SECTION) TO THE FRONT, REMAINING COMPANIES (SUB-DIVISIONS, OR SECTIONS) RIGHT (OR LEFT) WHEEL, &c., &c.

S. 30. *A Battalion in Line advancing in Double column of Companies, Sub-divisions, or Sections.*

The following description of an advance by Sub-divisions will apply equally to an advance by Companies, or Sections.

1. *Advancing by Sub-divisions.*

TWO CENTRE SUB-DIVISIONS TO THE FRONT, REMAINING SUB-DIVISIONS, ON THE MOVE, INWARDS—WHEEL. QUICK MARCH. FORWARD.	Left sub-division, Left wheel.* Right sub-division, Right wheel.† Two centre sub-divisions—Forward. By the left. * Forward. † Forward.

S. 31. *A Battalion formed in Line, retiring over a bridge, or through a defile, or retreating from a flank, or from both flanks in Rear of the Centre.*

1. *From a Flank, by Companies.*

RETIRE BY COMPANIES, FROM THE LEFT, IN REAR OF THE *RIGHT.*	*Captain of Left Company.* No. —— Right about face. Quick march. Left wheel. Forward. No. —— Right wheel. Forward. By the right. *Each Company in succession (except the right Company).* No. —— Right about face. Quick march—Left wheel. Forward. No. 1. Right about face. Quick march.

A Battalion will retire by Companies from the Right in rear of the Left, in like manner.

2. A Battalion will retire by Sub-divisions, or Sections, in the same manner as it retires by Companies; the Captain will give the words "Right about face" and "Quick march" to each of his sub-divisions, or sections; the proper leaders will then take command and give the words "Right (or Left) wheel, Forward."

3. *From both Flanks in rear of the Centre.*

The following description of the retreat by Sub-divisions will apply equally to a retreat by Companies, or Sections.

RETIRE BY SUB-DIVISIONS, FROM BOTH FLANKS, IN REAR OF THE CENTRE.	* *Two flank Sub-divisions.* Right Sub-division, Right about face. Quick march. Right wheel. Forward. Left Sub-division, Right about face. Quick march. Left wheel—Forward.
† *Captain of Left centre Company, to the two centre Sub-divisions.*	† Right about face. Quick march.
‡ *Corresponding Sub-divisions of the two Wings.*	‡ Left wheel. Right wheel. Forward.

S. 32. *A Battalion in Line, forming Open, Quarter distance, or Close Column.*

1. *Forming Open, Quarter distance, or Close Column, in rear of the Right Company.*

OPEN (QUARTER DISTANCE, OR CLOSE) COLUMN IN REAR OF No. 1. REMAINING COMPANIES, FORM FOURS RIGHT. QUICK MARCH.	Halt — Front, Dress. Steady.

2. *Forming Open, Quarter distance, or Close Column in front of the Right Company.*

OPEN (QUARTER DISTANCE, OR CLOSE) COLUMN IN FRONT OF No. 1. REMAINING COMPANIES, FORM FOURS—RIGHT. QUICK MARCH.	Halt — Front, Dress. Steady.

3. *Forming Open, Quarter distance, or Close Column in Front, or Rear, on the Left Company.*

A Battalion in line will be formed in column on the Left company in the same manner as it is so formed on the Right company, the remaining companies forming Fours to the left.

4. *Forming Open, Quarter distance, or Close Column on a Central Company.*

OPEN (QUARTER DISTANCE, OR CLOSE) COLUMN, RIGHT (OR LEFT) IN FRONT, ON No. —— FORM FOURS—INWARDS. QUICK MARCH.	Halt, Front, Dress. *Senior Major.* Steady.

5. *Advancing, or Retiring from either Flank of Companies.* *See Section 9 of this PART.*

6. *Forming Double Columns.*

Double Column of Companies, or Sub-divisions, will be formed from Line on the two centre companies or sub-divisions, in the same manner as single columns are formed.

DOUBLE COLUMN (OR QUARTER DISTANCE, OR CLOSE) DOUBLE COLUMN ON THE TWO CENTRE COMPANIES FACING TO THE REAR.	*The Companies, which move to the rear of the Line, will countermarch round the rear rank.*

FORMATION OF LINE FROM COLUMN.

S. 33. *Forming Line to the Front, from open Column, on any named Company.*

1. *Forming Line on the Front Company, from the Halt. Right in front.*

FORM LINE ON THE FRONT COMPANY, REMAINING COMPANIES FOUR PACES ON THE RIGHT BACKWARDS WHEEL. QUICK MARCH.	No. 1. Eyes Right, Dress. Eyes front. No. —— Halt. Dress. Eyes front.

FORM LINE. QUICK MARCH. *When the movement is completed.**	*In succession,* No. —— Right wheel. Halt. Dress up. Eyes front. *Senior Major.** Steady.

When the Column is Left in front, Line will be formed in the same manner as when Right is in front.

2. *Forming Line on the Front Company in a direction oblique to the Front of the Column.*

In this movement the front company will be wheeled back on its reverse flank into the direction required, the remaining companies will be wheeled back half the number of paces wheeled by the front company in addition to the four paces described in the preceding number of this section; the formation will be completed as already explained. If the leading company is wheeled up on the reverse flank, the line will be formed as described in Section 35 of this PART.

3. *Forming Line on the Rear Company from the Halt.*

Line may also be formed on the rear company of a column, the remaining companies first being faced to the right about, and then wheeled four paces on their right backwards, if right is in front, and on their left backwards, if left is in front, the captains remaining on the pivot flank. The movement will be performed in all respects as described in No. 1 of this Section, except that each company will move rear rank in front, and after it has wheeled into the alignment, it will receive the word "Forward" from its captain, move to the rear, until its proper front rank is in line with the rear rank of the halted company, and then be halted, fronted, and dressed up into line.

4. *Forming Line on a central Company.*

FORM LINE ON NO. *——; COMPANIES IN FRONT, RIGHT ABOUT FACE. FOUR PACES ON THE RIGHT (OR LEFT) BACKWARDS WHEEL.† QUICK MARCH.	No. ——.* Eyes Right—Dress. Eyes front. No. ——.† Halt—Dress. Eyes front.
FORM LINE. QUICK MARCH. *Front Companies.**	* Left (or right) wheel. Forward. Halt. Front—Dress up.
Rear Companies.†	† Left (or right) wheel. Halt—Dress up. Eyes front.

5. *An Open Column on the March, forming Line on the leading Company.*

If advancing, on the caution, FORM LINE ON THE LEADING COMPANY, the commanding officer will then give the words, REMAINING COMPANIES LEFT (or RIGHT) WHEEL, on which the leading company will continue to move straight to the front, and the remaining companies will wheel on moveable pivots, their captains changing flank by the rear. When they have completed the eighth of a circle, the commanding officer will give the word FORWARD, on which they will move on in echellon, and the captain of the leading company will give the word "Halt," change his flank, and then give the word "Dress." The movement will then be completed in the same manner as it is performed from the Halt.

If Retiring, the first part of the manœuvre will be performed in the same manner as when the column is advancing, except that the captains will not change their flanks on the caution, and the captain of the leading company will give the word "Halt—Front—Dress." The remaining companies will then form in the same manner as on a rear company from the halt.

S. 34. *An Open Column forming Line in inverted order.*

A battalion in column should be practised in forming line on the front, or rear company in inverted order, the right company on the left, and the left company on the right. The command will be given thus, IN INVERTED ORDER FORM LINE ON NO. 1 COMPANY, REMAINING COMPANIES, &c.

S. 35. *A Battalion in Open Column, forming Line to the Reverse flank.*

FORM LINE TO THE REVERSE FLANK.	*Leading Company.* No. —— Right (or left) wheel. Double—Forward. Halt—Dress up. *2nd Company.* Right (or left) wheel. Double—Halt—Dress up. Remaining companies in succession will form in like manner on the outward flank of the last-halted company. *Major.* Steady.

Columns of Sub-divisions, or Sections, will be formed to the reverse flank in like manner.

S. 36. *Forming Line to the Front from Double Column.*

Line will be formed to the front on the march, from double column, on the same principles as from a single column. The following description of the formation from double column of sub-divisions will apply equally to the formation from double column of companies, or sections.

FORM LINE ON THE TWO LEADING SUB-DIVISIONS, REMAINING SUB-DIVISIONS OUTWARDS WHEEL.—FORWARD.	Two centre sub-divisions—Halt. Four paces outwards—Close—Quick march. Left sub-division, Eyes left—Dress. Right sub-division, Eyes right—Dress. *The remaining sub-divisions will form in succession, as described in Section* 33 *of this Part.* Right (or left) sub-division, Left (or right) wheel—Halt—Dress up. Eyes front. *Senior Major.* Steady.

S. 37. *A Battalion in Double Column, forming Line to the Right, or Left.*

1. *Forming to the Right on the March.*

COLUMN BY THE RIGHT. FORM LINE TO THE RIGHT. RIGHT WING—RIGHT WHEEL INTO LINE.	Halt—Dress. Eyes front. *The companies, &c., of the Left wing will form successively to their reverse flank, in the manner described in Section* 35 *of this Part.* Halt—Dress up.

Line will be formed to the Left on precisely the same principles.

2. *Forming from the Halt.*

This movement may be performed from the halt, in which case the words will be FORM LINE TO THE RIGHT (or LEFT), RIGHT (or LEFT) WING, RIGHT (or LEFT) WHEEL INTO LINE. THE WHOLE, QUICK MARCH, &c., on which the companies, sub-divisions, or sections of the named wing will wheel into line, as directed in PART II., Section 4, or 9. The other wing will step off, and the rest of the evolution will be performed as already described.

DEPLOYMENTS.

S. 38. *A Battalion in Close, or Quarter distance Column, deploying into Line, to either flank.*

Deployments will invariably be made on a front company and by the *flank march of Fours*, unless the ground should render it necessary to *move in Files.*

1. *From Column, Right, or Left in front to the pivot flank.*

DEPLOY TO THE LEFT, OR RIGHT. FORM FOURS LEFT, OR RIGHT. QUICK MARCH. Steady.	No. —— Right (or Left)— Dress. Eyes front. No. —— Front turn. Halt. Dress up. Eyes front. Front turn. Halt. Dress up. Eyes front.

2. *From Column Right, or Left in front to the Reverse flank.*

The Deployment will be made on precisely the same principle as when made to the pivot flank.

S. 39. *A Battalion in Close, or Quarter distance Column, deploying to both flanks.*

DEPLOY OUTWARDS, ONE COMPANY (OR TWO, OR MORE, COMPANIES) TO THE RIGHT. FORM FOURS—OUTWARDS. QUICK MARCH.	Company, or companies, next in succession from the front move to the right.

S. 40. *A Battalion in Double column deploying.*

1. A Double column at close, or quarter distance may deploy on the two centre companies, or sub-divisions, in the same manner as a single column.

2. *A double column deploying to one flank.*

The wing nearest the point of appui will deploy on its rear Company, or Sub-division.

FORM FOURS—RIGHT (OR LEFT).
QUICK MARCH.

The other wing will take ground outwards in Fours, and, when the wing of formation has completed its deployment, will continue the formation of the line by deploying on its leading company, or sub-division.

S. 41. *A Battalion in Line changing Front by the intermediate Formation of open Column on any named Company.*

1. *To the Right, Left thrown forward, on the right Company.*

OPEN COLUMN IN FRONT OF NO. 1, REMAINING COMPANIES FORM FOURS — RIGHT. QUICK MARCH, &c. OR, OPEN COLUMN IN FRONT OF NO. 1, WHICH WILL WHEEL BACK ON ITS RIGHT. REMAINING COMPANIES, FORM FOURS RIGHT. QUICK MARCH, &c. RIGHT WHEEL INTO LINE. QUICK MARCH.	No. 1. On the right backwards wheel. Quick march. Halt. Dress. Eyes front.

2. *To the Left, Right thrown forward on the left Company.*

A line will change front to the Left on the left Company, in the *same manner as to the Right,* on the right Company; the left com-

pany being wheeled back on its left, if the new line is to be formed obliquely to the old one. The column will then be formed on its right in front, and it will be wheeled to the left into Line.

3. *To the Left, left thrown back on the Right company.*

OPEN COLUMN IN REAR OF NO. 1. REMAINING COMPANIES FORM FOURS RIGHT. QUICK MARCH, &c. OR, OPEN COLUMN IN REAR OF NO. 1, WHICH WILL WHEEL BACK ON ITS LEFT.	No. 1. On the Left backwards wheel. Quick march. Halt. Dress. Eyes front. The remaining Companies will then form Open column, right in front on the Right company, as directed in Section 32 of this PART. After which the Column will be wheeled into Line.

4. *To the Right, right thrown back on the Left company.*

A Line may change Front to the Right on the Left company, in the same manner as to the left on the right company. If the new Line is to be formed obliquely to the old one, the Left company will be wheeled back on the right, the column will be formed Left in front in rear of it, and then wheeled to the right into Line.

5. *To the Right, or Left on a Central company.*

OPEN COLUMN LEFT (OR RIGHT) IN FRONT, ON NO. ——, &c. OR, OPEN COLUMN LEFT (OR RIGHT) IN FRONT, ON NO. ——, WHICH WILL WHEEL BACK ON ITS RIGHT (OR LEFT). REMAINING COMPANIES, FORM FOURS—INWARDS. QUICK MARCH, &c. Right (or left) wheel into line. Quick march, &c.	No. —— On the Right (or Left) backwards wheel. Quick march. Halt. Dress. Eyes front. After the Column is formed, it will wheel into Line.

FORMATION OF SQUARES.

GENERAL PRINCIPLES.

1. *Use, and application of Squares.*—Men are formed into Square to resist attacks of Cavalry, and occasionally to protect baggage, or treasure against cavalry, or infantry. Squares may be formed two deep, or four deep. When troops are armed with breech-loaders, a two-deep square is sufficiently strong to resist cavalry, and gives ample space for the officers, band, &c., in the centre. The four-deep square, formed from quarter distance column, is more compact, but at the same time more exposed to danger from the fire of Artillery.

2. *Solid Square.*—Any compact mass of soldiers will be safe against cavalry, if the outside men kneel down and slant their bayonets outwards.

S. 42. A Battalion in Column, forming Square, Four deep.

1. *Forming Square four deep on the front Company of an Open column.*

ON THE FRONT COMPANY FOUR DEEP FORM SQUARE. QUICK (OR DOUBLE) MARCH.	*Remaining Companies, except the two in rear of the Column.* No. —— Sections—outwards. *Two rear Companies close up.* No. —— Halt. Right about face.

2. *Forming Square, four deep, on the Rear Company of an Open column.*

Eight Companies, right in front.

ON THE REAR COMPANY, FOUR DEEP, FORM SQUARE. RIGHT ABOUT —FACE. QUICK (OR DOUBLE) MARCH.	No. 6. Front—turn. Sections—outwards. No. ——. Front turn. Sections—outwards. No. 2—Halt—Front. No. 1—Halt—Front.

If a Column on the march is ordered to form Square, the leading Company will at once receive the words "No. —— Halt—Dress" from its Captain.

3. *Forming Square, four deep, on the centre, from Open column.*

Right in front.

ON THE LEFT (OR RIGHT) CENTRE COMPANY, FOUR DEEP, FORM SQUARE. RIGHT (OR LEFT) WING, RIGHT ABOUT FACE. QUICK (OR DOUBLE) MARCH.	Sections—outwards. Front turn. Sections—outwards. Sections—outwards. &c. &c. &c. *The Square will be completed on the Company of formation, as described in Nos. 1 and 2 of this Section.*

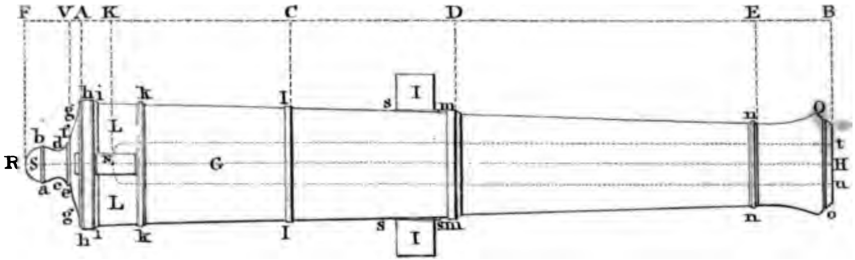
4. *A Column taking ground to a flank by Fours, forming Square, Four deep.*

When a battalion in open column taking ground to a flank by fours, is required to form square, the commanding officer will give the words ON THE LEFT (or RIGHT) CENTRE COMPANY FOUR DEEP FORM SQUARE, WINGS INWARDS TURN, on which the wings will turn inwards, the captain of the named company will give the words "Sections outwards," and square will be formed as already described. When the column is Right in front the square will form on the left centre company: when Left in front, on the right centre company.

5. *A Battalion in Quarter distance Column, forming Square, Four deep.*

A column at quarter distance will be formed into square in the *same manner as an open column*, except that the commanding officer

A BRASS GUN.



NAMES OF THE SEVERAL PARTS OF A GUN.

AB	*Length of the Gun*	L	*Vent Field*	h	*Base Ring*
AC	*First Reinforce*	N	*Vent*	i	*Base Ring Ogee*
CD	*Second Reinforce*	O	*Swell of the Muzzle*	k	*Vent Field Astragal & Fillets*
DE	*Chase*	VAK	*Breech*	l	*First Reinforce Ring*
EB	*Muzzle*	S	*Button*	m	*Second Reinforce Ring & Ogee*
FA	*Cascable*	a b	*Button Astragal*	n	*Muzzle Astragal & Fillets*
GH	*Bore*	c d	*Neck*	o	*Muzzle Mouldings*
RH	*Axis of the Piece*	e f	*Neck Fillet*	s	*Shoulder of the Trunnion*
I	*Trunnions*	g	*Breech Ogee*	t u	*Diameter of the Bore or Calibre*

PART III.

ORDNANCE, CARRIAGES, ETC.

ORDNANCE.

GUNS.

Guns are distinguished from each other by their metal, and weight of their shot.

A Gun (*Smooth bore*) *is divided into five parts*, which are named *Cascable*, *First re-inforce*, *Second re-inforce*, *Chase*, *Muzzle*.

The metal is made thicker towards the breech than at the muzzle, to strengthen the piece, for the elastic force of the Gunpowder is there greatest, and diminishes in power as the space it occupies is extended. The metal is made thinner towards the muzzle to make the gun lighter.

The Dispart is half the difference between the diameter of the Gun at the base ring, and at the swell of the muzzle. By affixing on the muzzle a piece of metal equal to the height of the dispart, the line of sight will be made parallel to the axis of the bore, and therefore an object within point-blank range can be seen. Howitzers, and some guns which have a patch or projection on the upper part of the muzzle, have no dispart, the semi-diameter of the muzzle with the patch added to it being equal to the semi-diameter of the base ring. Iron ordnance (Bloomfield's) are intended to have a degree and a half dispart, but the founder is allowed two-tenths of an inch variation in casting Iron ordnance, for any difference which there may be between the intended and actual diameter of the base ring, and muzzle.

Bronze Field Guns 6, and 3-pounders, 3 cwt. (4 feet), have a dispart of one degree; 3-pounders 2¼ cwt. (3 feet) have a degree and a half; and 12-pounders, and 9-pounders have one degree and a quarter.

The Angle of dispart is the number of degrees the axis of the bore would point above the object aimed at, when laid by the surface of the gun.

Point-blank range is when the piece is laid at the object without any elevation; the plane and the axis of the bore being parallel to each other. *Its distance is measured* from the muzzle of the piece (fired with the service charge of powder) to the first graze of the shot, or point at *which it first touches* the ground.

When a Shot is fired from a gun, it is acted upon by three forces:—

1st. The explosion of the Powder, which urges it forward.

2nd. The resistance of the Air, which tends to stop it.

3rd. The force of gravity, which causes it to descend.

When a shot has been fired from a gun one second of time, it has fallen $16\frac{1}{12}$ feet; in two seconds, $64\frac{1}{3}$ feet; in three seconds, $144\frac{3}{4}$ feet; and proportionally for every additional second.* For this reason it is necessary to give a certain degree of elevation to a gun: as, for instance, should *the time of flight* of a shot be two seconds, the gun must be pointed $64\frac{1}{3}$ feet above the object intended to be struck, because in that time it will have fallen through that space; therefore, the more distant the object is, the greater must be the elevation given to enable the shot to reach it.

There are three modes of extending the range of a Shot without increasing the charge of powder, viz.:—

1st. By raising the piece to a higher level.

2nd. By giving its axis greater elevation.

3rd. By eccentric projectiles; experiments having shown that if the centre of gravity is placed directly above the centre of figure the range is greatly increased.

A Tangent scale is affixed to the breech of Guns, and Howitzers, by means of which the requisite elevation may be given, and the object seen at the same time. This scale has divisions, called degrees, marked on it, and it is placed in a groove at the breech, from which it can be raised (being fastened by a screw) to give the necessary elevation.

The divisions on the Tangent scale may be approximately found by multiplying the length of the piece in inches, from the base ring to the swell of the muzzle, by ·017455, and the product will give the length, nearly of each degree, or division on the tangent scale. By subtracting the dispart from this product, the length of the tangent scale above the base ring for one degree of elevation will be obtained.

When there is no dispart sight, the scale can only be used for elevations above the dispart angle. In this case the divisions must be marked, considering the top of the scale as the length corresponding to the dispart angle.

Tangent Scales. LAND SERVICE.

Tangent scales for Bronze ordnance (both for land and sea service) are of metal, and fit into a groove bored in the breech of the gun.

There are three kinds of tangent scales for iron guns used in the land service.

1. *The metal scale*, fitted to a metal block attached to the breech of the gun. This is used with Millar's dispart sight, also with the muzzle sight, in those guns where the shape of the breech admits of the scale being made of sufficient length.

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* *Note.—Vide* "Motion," "Forces," &c., Velocity, Gravity, and Amplitude, *Part xiii.*

2. No. 1 wooden tangent scale is issued with Millar's sights, in addition to the metal scale, and is used for giving elevations beyond what can be obtained by the latter. Those now issued are made to fit the block with great accuracy. A piece of metal is also screwed on, into which the head of the metal scale is intended to fit. The latter should be raised as much as possible, and screwed tight, but not to prevent the wooden scale resting upon the top of the block.

3. No. 2 wooden tangent scale is intended for guns not fitted with Millar's sights. They can only be used for giving elevations above the dispart angle of the gun.

Tangent Scale. SEA SERVICE.

For Sea-service iron ordnance, all breech tangent scales are made of hexagonal metal tubing, on the sides of which the elevation and corresponding ranges are marked. They are fitted to gun-metal blocks attached to the breech of the guu. There is also issued for broadside guns, a wooden tangent scale, which is applied to the quarter sight, and by means of which the elevation of the gun may be determined.

Sights.

Sights for land-service guns (cast) have Millar's foresight, though they are not all exactly alike, there being a difference in the shape of the bottom to suit the curve of the gun. They are marked for the nature of the gun for which intended; and after having been fitted, are marked for each particular gun. Thus 10-inch 84 cwt., No. 35. No Bronze guns, or Howitzers, or Iron Howitzers have foresights, they being always laid by the muzzle.

Hind Sights.

For land-service Iron guns there are 3, viz., Millar's hind-sight, Wood tangent scale No. 1. Do. No. 2.

Millar's Hind-sight.

These consist of a block of gun-metal, with a thumb screw, lead packing, a brass scale, and 3 screws. The blocks are of 5 different patterns. The scale differs for each nature. It is tightened by a thumb screw working against a brass spring in the block. They are all graduated to ¼ degrees.

Wood Tangent Scale, No. 1.

This is issued with all iron land-service guns, and is graduated up to 8 degrees for all natures. A brass staple is fixed on behind the scale, into which the head of the brass tangent scale, when elevated, fits. It is graduated in yards as well as degrees, and is marked for the nature of the gun for which intended.

Wood Tangent Scale, No. 2.

This scale, like the last, is of walnut-wood, graduated also to 8 degrees, and with a scale of yards on it. All the degrees, however,

are reckoned from the long radius. It is intended for use when other sights are lost or broken. It is not fixed on the gun, but, when used, is held in its place.

Sights for Bronze guns; and Bronze, and Iron Howitzers.

These scales are let into sockets in the guns, and are secured by a gun-metal thumb screw. Each scale is graduated and marked for the particular nature of gun for which intended: graduated up to 8°.

Sea-service Sights.

All Sea-service Iron guns have Miller's foresight, the same as all the cast-iron land-service guns. There are 4 natures of Hind-sights.

1. Hexagon Hind-sight.
2. Hexagon Brass slides, in sets.
3. Hexagon Wood slides. Do.
4. Wood Side scale.

1. *Hexagon Hind-sight.*

This corresponds to Millar's hind-sight for land-service guns. It is fitted into a gun-metal block with a thumb screw, but without the pin for holding No. 1 Wood scale. The Scale is a hollow brass hexagon graduated on the six sides.

1st side—degrees of elevation marked —⊖—.
2nd side is a scale of yards, range for shells full charge, marked S. F.
3rd side is a scale of yards for shells with distant charge, marked S. D.
4th side is a scale of yards for shot with a distant charge, marked D.
5th side is a scale of yards for shot with full charge marked F.
6th side is a scale of yards for shot with reduced charge, marked R.
The 8-inch, and 10-inch guns have no D, F, or R scales.

Hexagon Brass Slides, in sets.

These correspond with No. 1 Wood scale for Land-service Iron guns, and consist of 1, 2, or 3 slides let into the sight block, in place of the brass tangent scale. They are used only for the following guns when mounted as pivots, viz., 10-inch 84, or 86 cwt.—1 slide graduated from 7° to 10°.

8-inch 60 cwt., or 65 cwt.—two slides, the first from 5° to $7\frac{1}{2}$°, and the second from $7\frac{1}{2}$° to 10°.

68-p^{r}., 95 cwt.—1 slide—7° to 11°.
32-p^{r}., 58 cwt.—2 slides—4° to 7°.
" " 7° to 10°.
32-p^{r}., 56 cwt.—3 slides—4° to 6°.
" " 6° to 8°.
" " 8° to 10.
These slides are never used but for Pivot guns.

Hexagon wood slides, in sets.

These are exactly like the brass ones, as to shape, and graduation. *They are intended* as spare slides, being issued in the proportion of 1 set *to every six guns of* the same nature.

32-p^r^., 50 cwt. (Monk's A) 2 slides—5° to 7°; and 7° to 10°.
„ 48 cwt., 2 slides, 5° to 7°; and 7° to 10°.
„ 45 cwt. (Monk's B), 2 slides, 5° to 7°; and 7° to 10°.
„ 40 cwt. (Congreve), 5° to 8°; and 8° to 10°.
„ 42 cwt. (Monk's), 5° to 7°; and 7° to 10°.
„ 39 cwt. „ 5° to 7°; and 7° to 10°.
„ 32 cwt. „ 4° to 7½°; and 7½° to 10°.
„ 25 {high and low muzzle} 5° to 7½°; and 7½° to 10°.

Wood Side Scale.

This scale is used for Guns mounted only on Harvey's carriages.
32-p^r^, 32-cwt., 6 ft. 6 in.; 32-p^r^, 25 cwt., 6 feet, 6-p^r^. Broad gun.
This scale is graduated to 12° elevation, and 6° depression.

Sights for Bronze Guns, or Howitzers, Sea Service.

None of these have foresights, except the 6-pounder, when used as a Broadside gun. The hind-sight is the same as for Land-service Bronze guns.

Carronade sights.

The Foresight for the Carronade is a block of gun-metal, let into the original sight recess. The Hind-sight consists of a gun-metal Block, with a brass semicircular scale let into it.

The line of metal is an imaginary line drawn along the surface of the metal between the two sights.

The line of metal Elevation is obtained by laying a Gun at an object by means of the sights, without giving any elevation; from the thickness of metal at the breech, the line of metal elevation varies from one to two degrees.

The Centre of metal is indicated by a line drawn from the sight of the base ring to that of the swell of the muzzle.

Windage is the difference between the diameter of the bore and that of the shot. The windage formerly allowed was one-twentieth the diameter of the shot, but it is now reduced considerably: (Field Guns have only one-tenth of an inch), and this diminution of windage is very beneficial, longer ranges being obtained with the same charges of powder, and also greater precision of fire.

The Vent, for every nature of Ordnance, is two-ninths of an inch in diameter.

Bouching a gun is fixing a pure copper vent into it; which is done by drilling a hole in the piece, where the vent is usually placed, about one inch in diameter, and screwing therein a piece of wrought copper, with a vent of two-ninths of an inch through the centre of it.

Tertiating a gun is examining the thickness of metal, whether the bore is perfectly straight, the trunnions properly placed, &c. It is performed by means of calliper compasses, and other instruments.

Quadrating a gun is ascertaining if it is properly placed on its carriage, *and if the wheels are of an* equal height.

A gun is honeycombed when the surface of the bore has cavities, or holes in it.

The length of a gun is ascertained by measuring it from the rear of the base ring to the face of the muzzle.

The Calibre of a gun is the diameter of the bore.

To find the length of a gun, in feet and inches, its length in Calibres being known—

Divide the product of the number of Calibres and the diameter of the bore, in inches, by 12, and the quotient will be the length in feet and inches.

To find the Number of calibres in the Length of a gun.

Divide the length of a gun in inches by the number of inches in the calibre.

Gun metal is a compound of 8 lb. or 10 lb. of tin, to 100 lb. of copper. The property of tin being to harden, the largest proportion (10 lb.) is used for mortars, they requiring a greater degree of hardness than guns.

Ordnance cast of gun metal are generally designated *Bronze Ordnance.*

Service charges of Powder.

For heavy guns (Smooth bore) . $\frac{1}{3}$ the weight of the shot.
For light do. . . . . $\frac{1}{4}$ do. do.

The Point-blank range of Iron 32, 24, 18, and 12-pounders with solid shot varies from 380 to 260 yards; from which to 1200 yards, every $\frac{1}{4}$ degree increases the range about 100 yards, and from 1200 to 1500 yards, every $\frac{1}{4}$ degree increases the range about 50 yards.

The Point-blank range of Bronze, 12, 9, and 6-pounders, with solid shot, is 300 yards, and from which to 700 yards, every $\frac{1}{4}$ degree elevation increases the range 100 yards; from 700 to 1000, every $\frac{1}{4}$ degree increases it 75 yards, and from 1000 to 1200, every $\frac{1}{4}$ degree increases it 50 yards.

The Point-blank range of Bronze, 12, 6, and 3-pounders is 200 yards, from which to 600 yards, each $\frac{1}{4}$ degree increases the range 100 yards, and from 600 to 1000, each $\frac{1}{4}$ degree increases it 50 yards.

Note.—For Weight, Dimensions, Ranges, Charges, &c., vide Tables.

HOWITZERS.

Howitzers are a short description of Ordnance, either Bronze or Iron, and are used for projecting Shells. Their principal advantages are that they can be more easily loaded, and are considerably lighter, in proportion to their calibre, than Guns; and they also may be used as Mortars. They have no dispart, the diameter of the base ring, and *swell of the muzzle* being equal, except in the 24, and 12-pounders; *which, however, are* provided with a patch to make up the difference.

Note.—*Vide* Tables for Weights, Dimensions, Ranges, Charges, &c.

CARRONADES.

A Carronade is a short piece of Iron Ordnance, with a loop under the reinforce instead of trunnions. Its construction is materially different to that of guns; having a chamber; a part scooped out inside the muzzle forming a cup; also a patch on the reinforce. They take their name from the Carron Foundry (where they were first cast for the Navy in 1779), are considerably lighter than Guns of similar calibres, and are fired with charges of about one-twelfth the weight of the shot.

Carronades are chiefly used on board ship, but occasionally in casemates, and retired flanks of fortresses.

The highest charge is one-eighth the weight of the shot.
The lowest charge one-sixteenth do. do.

Note.—For Weights, Dimensions, Ranges, &c., vide Tables.

MORTARS.

Mortars differ from Guns in the construction of their bore, and also in their form, which is considerably shorter, the metal being much thicker, and the trunnions being at the extremity of the breech.

They are used for throwing Shells into a town, or battery, setting fire to and overthrowing works, blowing up magazines, and breaking through the roofs of barracks, casemates, magazines, &c. They are distinguished from each other by the diameter of their bore. Their chambers are in the form of a frustrum of a cone, in which the powder is more concentrated; the Shell fits close to the sides of the piece, and thereby receives the whole force of the expansion of the powder. The greatest charges their chambers will contain, and the corresponding Ranges, are as follows:—

	13-inch. Land Service.	10-inch. Land Service.	8-inch. Land Service.
Greatest charge	9 pounds.	4 pounds.	2 pounds.
Greatest range	2706 yards.	2536 yards.	1726 yards.

When Mortars are used in firing on Inclined planes, up, or down hill, should the inclination be considerable, take half the angle it makes with the horizon, and add it to, or subtract it from 45 degrees (which is for a medium plane), and it will give *the greatest range upon the required plane.*

Note.—Vide Tables of Dimensions, Weight, Charges, Ranges, &c.

VALUE OF ORDNANCE.

BRONZE ORDNANCE.

Dependent on the market price of metals; at present the value of *gun-metal is about £120 a ton.*

IRON ORDNANCE.

The value is variable according to the market price of iron; at present the value is about £20 a ton.

PROOF OF ORDNANCE.

All natures of Ordnance undergo several kinds of proof before they are received into the service:—

1st. They are gauged as to their several dimensions, internal and external; as to the justness and position of the bore, the chamber, vent, and trunnions, &c.

2nd. They are fired with a regulated charge of powder and shot, being afterwards searched to discover irregularities, or holes produced by the firing.

3rd. By means of engines, an endeavour is made to force water through them.

4th. They are examined internally by means of light, reflected from a mirror.

IRON GUNS.

The guns are first examined as to their proper dimensions, in which no more than ·3 of an inch variation is allowed; and in the diameters of the bore only ·033; but in the position of the bore ·25 of an inch out of the axis of a piece is allowed.

They are then fired twice with the charge in the following table, with one shot and two high junk wads, and examined with a searcher after each round.

In this examination they must not have any hole or cavity in the bore of two-tenths of an inch in depth behind the first reinforce ring, or one-fourth of an inch in depth before this ring.

PROOF CHARGES.

Nature	10 In.	8 In.	68 Pr.	56 Pr.				
Charge, in pounds	20	18	28	28				
Nature	42 Pr.	32 Pr.	24 Pr.	18 Pr.	12 Pr.	9 Pr.	6 Pr.	3 Pr.
Charge, in pounds	25	21½	18	15	12	9	6	3

BRONZE GUNS.

From 3 to 12-pounders, the diameter of the bore must not vary more than ·025 of an inch, nor in any dimensions more than ·2.

PROOF CHARGES.

Nature	12-Pr.	9-Pr.	6-Pr.	3-Pr.
Charge	5 lb.	3½ lb.	2 lb.	1 lb.

The 12 and 9 pounders are fired twice, the remainder three times.

Any hole ·15 of an inch upwards, or sideways in the bore, or ·1 in the bottom between the breech and first reinforce; or ·2 of an inch upwards, or sideways, or ·15 in the bottom of the bore before the first reinforce ring, will be sufficient to condemn them.

MORTARS, AND HOWITZERS.

The exterior dimensions are in no respect to deviate more than ·1 of an inch in the 10, and 8 inch Howitzers, and ·05 of an inch in the 24, and 12 pounder Howitzers, and Royal and Coehorn Mortars, and Howitzers. Their bores and chambers must not deviate from their true diameters, or positions more than ·025 of an inch.

PROOF CHARGES.

The Brass Mortars, and Howitzers are fired twice with their chambers full of powder, and an iron shell. The Mortars on their own beds at an elevation of about 75 degrees, and the Howitzers on their carriages at an elevation of about 12 degrees. The Iron Mortars are proved with a charge equal to the full chamber, and a solid shot equal in diameter to the shell. Royal or Coehorn Mortars, and also 24, and 12 pounders, or Royal Howitzers, having a hole of ·1 of an inch in depth in the chamber, or ·15 of an inch in the chase are rejected. A hole ·15 of an inch in depth in the chamber, or ·2 of an inch in the chase is sufficient to condemn the 10, and 8 inch Howitzers. For the 13-inch Sea-service Mortar a cylinder weighing 4½ cwt. is used for proof.

CARRONADES.

The bores, and chambers of Carronades must not deviate more than ·05 of an inch from their true dimensions, and positions.

PROOF CHARGES.

They are proved with two rounds, with their chambers full of powder, and one shot and wad. A hole of ·2 of an inch in depth in the bore, or ·1 in the chamber condemns the piece.

WATER PROOF.

All Ordnance, after having undergone the before-mentioned proofs, and the subsequent searchings, are subject to the *Water proof*. This is done by means of a forcing pump, having a pipe or hose fitted and secured to the mouth of the piece, and a plug to stop up the vent.

After two or three efforts to force the water through any honeycombs, or flaws which there may be in the bore, they are left to dry, and generally the next day examined by light reflected from a mirror. If the bore should contain any small holes, or flaws which have not been discovered by the former proofs, they are very readily found by this, as the water will continue to weep, or run from the holes, after the solid parts of the bore are perfectly dry.

When a gun bursts in proving, the remainder in proof at the same *time are subjected to another proof* round.

MARKING OF GUNS.

Condemned Ordnance are distinguished by a cross cut on the top of the Gun, and a white painted cross on the face of the piece. The Broad arrow on the gun indicates that the piece has been proved, and admitted into the Service. All guns proved since September 1857 have the Proof number, and the year of proof on the first reinforce. This proof number is also called the Register number.

Condemned Shells are thus marked:

F — For Fuze hole faulty.

N × for Non-concentric. W × for Water-proof.

INSTRUCTIONS FOR THE CARE, AND PRESERVATION OF IRON ORDNANCE.

Great attention should be paid to the care and preservation of iron Ordnance when in Depôt, or on Service, to prevent the irreparable injury Guns sustain from rust and corrosion.

With this view the first step to be taken is to clear their bores and exterior surfaces from all rust and dirt, which is done on the inside with circular Spring Scrapers, fixed on the end of a long shaft or handle: these scrapers are made to press strongly on the sides of the cylinder, and by being drawn backwards and forwards by two or three efficient labourers, will remove the rust, and, if not in a very bad state, will restore a regular smooth surface; the bottom or end of the bore is also scraped with a tool for that purpose, and the vent is opened by passing a square steel rimer of its diameter through it, gently turning the tool round until the vent is clear; after which the bore must be well brushed out, first with a hard round brush, and then with a Turk's-head brush, so that not the least dirt remains in it. This being performed, the first coat of lacquer may be laid on, to which, when dry, a second is to be added. This is done with a common painter's brush, fixed vertically on the end of a staff sufficiently long to reach down the cylinder; and the bottom of the bore is lacquered by another brush fixed horizontally at the end of the staff; the outside or exterior parts of the pieces are also to be well scraped with an old sea-service sword, or steel tool of that nature, tolerably sharp, especially about the mouldings, where former coatings and dirt have accumulated; and when the rust will not give way, it should be slightly hammered, so as to loosen it. These operations must be continued until the whole coat of old paint, rust, or dirt, is completely removed, after which the dust must be well brushed or rubbed off, and the piece will then be fit to receive its first coat of anticorrosion, to which, when dry, a second is to be added.

Before the work is commenced the pieces should be arranged as nearly as possible in the places where they are to remain, as too much rolling is apt to disturb the coating of paint, especially before it has gained sufficient hardness to be durable.

The following objects also require to be particularly attended to, viz.:

In skidding Guns, &c., care must be taken that they are laid under metal, so that their muzzles may be sufficiently inclined downwards to prevent rain or any moisture lodging, and the bores from time to time should be swept out, as dust or sand blowing into them and being suffered to remain, would be very destructive; nor should the Guns be ever stacked one over the other, if the space where they are kept is sufficiently large to admit of their being laid in single tiers.

After the Ordnance is once got into a complete state of preservation, by following these instructions, very little trouble or expense will attend their being kept so, for a slight coat of anticorrosion on the exterior, and a thin coat of lacquer in the cylinder every three or four years, is all they will require, provided they are every now and then brushed out as before stated.

On coating the Guns, it may be found useful to let the painter mark on them the date, which will show how long it lasts, as this may differ at different stations, especially such as are exposed to much damp air, and it will afford the means of calculating the necessary demands of articles for this purpose at stated periods.

The same rules are to be observed in the preservation of all iron Ordnance mounted on works, with regard to the application of lacquer, and anticorrosion, and the precautions of keeping the pieces laid under metal, and frequently brushing out their bores, &c., as recommended in the foregoing instructions.

MIXTURE OF INGREDIENTS FOR COATING, AND LACQUERING IRON ORDNANCE.

	lb.		lb.
Anticorrosion	40	Red lead, as a drier . . .	3
Black (Grant's) ground in oil	4	Linseed oil . . . gallons	4
		Turpentine (spirits of) pint	1

This mixture, when well stirred, and incorporated, will be fit for use, but, as by long keeping in this state it becomes hard, no more should be mixed than is required for present use.

BLACK LEAD LACQUER, FOR THE BORE, OR CYLINDER.

	lb.		lb.	oz.
Black lead (Cumberland) . .	9	Red lead	2	8
Linseed oil . . . . gallons	4	Lamp black, or wad .	0	4

The oil to be boiled, and the paint to be well ground. This will keep. Great care should be taken in boiling the oil, as any damp falling in would cause an explosion.

INSTRUCTIONS FOR LACQUERING SHOT, AND SHELLS.

All Shot, and *Shells (including* Shrapnel) are first to be cleaned *exteriorly by the machine, or otherwise*, and then such as are found

sufficiently correct, and up to their proper gauge, are to be twice lacquered with the following composition, leaving sufficient time between for the coats to become perfectly dry, and hard. The warmest weather is the proper time for this operation. Ten labourers can examine, clean, and lacquer with two coats one thousand shot in a day, provided the weather be favourable.

COMPOSITION.

Grant's black 40 lb. Red lead 5 lb. Raw linseed oil 5 gallons.

The red lead is to be ground into a part of the oil, in order that the whole of the ingredients may be thoroughly incorporated.

TO RENDER ORDNANCE UNSERVICEABLE BY SPIKING, ETC.

The most effectual method of rendering Guns unserviceable, or of no further use, is by removing one or both of the trunnions, which may be done by striking near its end with a sledge hammer; or by firing a shot against it from a carronade, or howitzer, the muzzle of the piece being placed near the trunnion.

Bronze Ordnance may also be rendered unserviceable by firing whole or broken shot into the bore from another piece; or by firing a shot against the chase, which generally bulges the metal within the bore.*

For spiking Ordnance, two kinds of spikes are used:—

1st. *The Common spike*, which is 4 inches long, ·27 inches in diameter at the head, and about ·1 at the point. It is driven as far as it will go into the vent, and afterwards broken off close to the gun.

2nd. *The Spring, or Temporary spike*, which is ·17 in diameter, and varies in length from 2·8 to 13·55 inches, according to the nature of the piece. It has a flat head to prevent its falling through the vent into the bore, and also a spring about two inches in length, which extends from the point towards the head. In passing through the vent, this is compressed, but as soon as it is clear of the metal, it expands and cannot be withdrawn, unless it is again compressed sufficiently to allow its being again drawn into the vent, which may be done by pressing a rammer head against it, provided the spring is towards the muzzle, which may be known by a small notch cut in the head of the spike to point out its direction.

A long spike with a soft point may be driven into the vent, and the end projecting into the bore clenched; which, as well as either a common nail or even a wooden peg, would answer as a temporary expedient if a proper spike were not at hand. Should a momentary abandonment of the guns become unavoidable, by taking away the cap-squares, elevating screws, quoins, linch-pins, or side-arms, the Enemy will be prevented using them for some time.

* *When a shot is jammed in a gun, and cannot be rammed home to the cartridge,* destroy the charge by pouring water down the vent and muzzle, until the ingredients are dissolved, and cleared out of the bore; then introduce a small quantity of powder through the vent, and blow out the shot.

UNSPIKING ORDNANCE.

If a gun has been spiked with a Common steel spike, load with a charge of powder equal to half the shot's weight: lay a leader of quick match along the bore, and double shot the gun, introducing the shot, however, very carefully.

By affixing a piece of slow match to the end of the quick match which reaches to the muzzle, the gun may be easily and safely fired. Should the spike not be removed, the operation may be repeated.

When Bronze guns have been spiked, it would be advisable, a day or two before making the above experiment, to scratch round the spike with a graver, and pour a few drops of Sulphuric, or Nitric acid into the circle, which, being repeated, will find its way down between the spike, and the metal, particularly if the former is not perfectly round. When the gun cannot be unspiked by the above-mentioned operations, make a large fire round the breech to soften the spike, and after the gun has been gradually cooled, the spike may generally be removed by using the drill.

When a gun cannot be unspiked, the only means of rendering it serviceable is to drill another vent, about half an inch from the original one.

To drill a new Vent will require about an hour per inch. Care must be taken that a very small drill is first used, and afterwards one rather less than the diameter of the vent, otherwise the vent will run the risk of being too much enlarged.

LIST OF SERVICE

	RIFLED							
	Breech Loading.							
	7-inch.		Wedge.		40-Pounder.	20-Pounders.		
			64-Pr.	40-Pr.				
Weight. . . . . . cwt.	82	72	61	32	32 & 35	16	15	13
Length . . . . . ft. in.	10 0	9 10	9 2	8 2	10 0& 10 1	8 0	5 $6\frac{1}{8}$	5 $6\frac{1}{8}$
Calibre . . . . in.	7	7	6·4	4·75	4·75	3·75	3·75	3·75
Charge lbs. oz. — Battering. . . .	..	..	..	..	..	..	..	..
Charge lbs. oz. — Service	11 0	10 0	8 0	5 0	5 0	2 8	2 8	2 8
Charge lbs. oz. — Saluting, or exercising	..	..	..	3 0	3 0	1 8	1 8	1 8
Shot, lbs. oz. — Solid—cast. . .	..	..	..	41 3	41 3	20 9	20 9	20 9
Shot, lbs. oz. — Palliser . . .	..	..	..	..	..	..	..	..
Shot, lbs. oz. — Case.	67	67	48	30	30	15	15	15
lbs. oz. Shell — Common, empty .	83 4 & 98	83 4 & 98	60 0	38 5	38 5	20 8	20 8	20 8
lbs. oz. Shell — Palliser	..	..	..	..	..	..	..	..
lbs. oz. Shell — Double	..	..	..	..	..	..	..	..
lbs. oz. Shell — Segment lbs. oz.	98 0	98 0	62 0	39 0	39 0	19 10	19 10	19 10
lbs. oz. Shell — Shrapnel . . .	..	..	..	..	..	..	..	..
lbs. oz. Bursting charge. — Common . . .	6 8 & 7 10	6 8	4 8	2 4	2 4	1 2	1 2	1 2
lbs. oz. Bursting charge. — Double	..	..	..	..	..	grains.		
lbs. oz. Bursting charge. — Palliser. . . .	..	..	..	..	..			
lbs. oz. Bursting charge. — Segment . . .	3 2	3 2	2 12	0 13	0 13	700	700	700
lbs. oz. Bursting charge. — Shrapnel . . .	..	..	..	..	..	..	..	..
						C S*	C S	C S
Fuzes. — Arm-strong's — E Time. . . .	..	..	..	..	..	1 1	1 1	1 1
Fuzes. — Arm-strong's — Percussion — C. .	..	..	..	..	..	1 1	1 1	1 1
Fuzes. — Arm-strong's — Percussion — Pillar	1	1	1	1	1	..	..	..
Fuzes. — Boxer's time. — For B.L. R. Ord.	20s. 9s. 1	1	1	1	1	..	..	..
Fuzes. — Boxer's time. — „ M.L. Rifled or Smooth-bore	20s. 9s	..	..	..	..	..	..	..
Fuzes. — Boxer's time. — Common . .	..	..	..	..	..	..	..	..
Fuzes. — Pettman's Gen. Service .	..	..	..	..	..	..	..	..

* C, Common. S, Segment.

GUNS, AND AMMUNITION.

GUNS.										
Breech Loading.			Muzzle Loading.							
12-Pounder.	9-Pounder.	6-Pounder.	13-inch.	12-inch.	9-inch.	8-inch.	7-inch.		64-Pounder (3 patterns).	7-Pr. mountain (steel).
8	6	3	23 tons	23½ tons	12 tons	9 tons	7 tons	6½ tons	64 cwt.	2 cwt.
6 0	5 2	5 0⅛	14 3¼	14 3½	12 3	11 4¼	11 10⅕	10 5¼	9 3½ 9·5 (B) 9·3 (D)	2 7¾
3	3	2·5	13	12	9	8	7	7	6·3	3
..	..	..	70	..	43	30	22	22	..	..
1 8	1 2	0 12	50	..	30	20	14	14	8	10 oz.
1 0	1 0	..	..	..	15	12	10	10	6	..
11 9	8 13	6 3	..	..	..	..	..	..	..	..
..	..	..	..	..	250	180	115	115	..	..
9	7	4 8	..	..	100	70	67	67	..	5 4
10 12	8 2½	..	568	..	232	167	106 12	106 12	60	6 14
..	..	..	600	..	247	178	115	115	..	..
..	..	..	..	..	..	..	146 12	146 12	..	..
10 7	8 5	5 7	..	..	..	..	..	..	..	..
..	..	..	..	..	249 4	181 6	110 8	110 8	62 11	7 5½
0 8	0 6	..	..	..	18	13	8 4	8 4	4 13 & 7 0	7
grains.			..	..	..	..	12 12	12 12	..	..
			..	..	3 2	2 0	..	..	..	..
550	300	200	..	..	..	..	..	..	1 14	..
..	..	..	..	..	..	..	..	..	..	..
C S	C S	S								
1 1	1 1	1	..	..	..	..	..	..	..	..
1 1	1 1	1	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	1	..
..	..	..	1	..	1	1	1	1	1	..
..	..	..	1	..	1	1	1	1	1	..
..	..	..	..	..	..	..	..	..	..	1
..	..	..	1	..	1	1	1	1	1	..

LIST OF SERVICE GUNS, AND AMMUNITION—*continued.*

		MORTARS.									
		Iron.						Bronze.			
		13-inch.		10-inch.		8-in.		5¼-in. Royal.		4⅖-in. Coehorn	
Weight	cwt.	100 100ª 81+ 36		52ª 18		9		1¼		¾	
Length	ft. in.	5 4 4 5 3 2 3 4		3 10 2 7		2 2		1 3		1 1	
Calibre	in.	13 13 13 13		10 10		8		5·62		4·52	
		Charge.	Fuze.	Charge.	Fuze.	Charge.	Fuze.	Charge.	Fuze.	Charge.	Fuze.
	yds.	lb. oz.	in.	lb. oz.	in.	lb. oz. dr.	in.	oz. dr.	in.	oz. dr.	in.
Range	400	1 12	1·8	0 15	1·8	0 9 8	1·8	5 0	1·75	2 12	1·75
	500	2 1	2·	1 2	2·	0 10 12	2·	5 8	1·85	3 4	1·85
	600	2 5	2·2	1 4⅛	2·2	0 13 12	2·2	6 0	1·95	3 12	1·95
	700	2 9	2·4	1 7¼	2·4	0 15 4	2·4	6 8	2·1	4 5	2·1
	800	2 13¼	2·5	1 10	2·5	1 0 10	2·5	7 1	2·3	4 15	2·3
	900	3 2	2·6	1 12	2·6	1 2 0	2·6	7 11	2·45		
	1000	3 7	2·7	1 14	2·7	1 3 8	2·7	8 6	2·55		
	1100	3 11	2·8	2 1¼	2·8	1 4 12	2·8				
	1200	4 0	2·9	2 4⅝	2·9	1 6 0	2·9				
	1300	4 5	3·0	2 6¼	3·0						
	1500	4 15	3·2	3 0	3·2						
	1700	5 10	3·4	3 4	3·4						
	2000	..	..	..	..	2 0 0					
	2400	..	..	4 0							
	2900	9 0									
Shells, Mortars	lbs.	195		87		46		16		8	
Shot, Sand, with bottoms	lbs.	100		50		50					
Carcasses, filled	lbs.	234		105		53		19¼		9⅜	
Light Balls, Ground	lbs.	..		64		33		10¼		5	
,, Parachute		..		31⅝		15		6⅝			
Fuzes: Large		1		1		1		..		5	
Fuzes: Small		..		..		..		1			
Fuzes: Parachute		..		1		1		1			
Charges for Shells	lbs. oz.	10 15		5 4		2 9		1		7 oz.	

ª Blomefield's.

LIST OF BORED-UP GUNS.

	cwt.			cwt.
32-pr.	40	from	24-pr.	41
32 ,,	39	,,	24 ,,	40
32 ,,	32	,,	24 ,,	33
24 ,,	22	,,	12 ,,	24
24 ,,	20	,,	12 ,,	22
18 ,,	20	,,	12 ,,	22
18 ,,	15	,,	9 ,,	17

MARKS ON GUNS, REFERRING TO THEIR VENTS.

Copper cone vented when new. { CV N C

Copper cone vented after issue. { CV C

Copper through vented CV

[The initial of the out-station at which a gun is re-vented to be added under the above.]

Sentence, after inspection (in white paint).

Serviceable ↑

Condemned +

Requires cone venting $\overset{o}{V}$

" through venting $\overset{T}{V}$

Otherwise repairable R

List of Service Guns, and Ammunition—*continued.*

	Smooth-bore Guns.										
	Wrought-iron.		Cast-iron.								
	150-pr.	100-pr.	68-pr.		10-in.	8-in.			56-pr.○	42-pr.	
Weight . . . cwt.	12 tons.	6½ tons.	112b○	95b	86b	65e	60c	54b	97d	84d	67b
Length . . . ft. in.	12 3	10 3	10 10	10 0	9 4	9 0	8 10	8 0	11 0	10 0	9 6
Calibre . . . in.	10·5	9·0	8·12	8·12	10	8·05	8·05	8·05	7·65	6·97	6·97
Charge { Battering . . . lb. oz.	40	25	..	..	..	..	..	..	..	..	..
Charge { Service . . . ,,	35	20	18	16	12	10	10	8	14	14g	10 8
Charge { Saluting or Exercising ,,	20	12	8	8	8f	5	5	5	8	8	8
Shot { Solid . . . lb. oz.	150.	94 6	66 3½		..	..			55 8	41 6	
Shot { Steel . . . ,,	..	..	..		..				..	..	
Shot { Grape . . . ,,	..	..	67		82 12	67			69 8	48 11	
Shot { Case . . . ,,	..	100	O.P. 47 4 N P. 50 8		79 3 82	47 4 50 8			52 5	45 5	
Shell { Common, empty . ,,	..	..	47 4½		79 4	47 4½			40 2	29 11	
Shell { Naval . . . ,,	104	66 0	47 13½		79 13	47 13½			..	..	
Shell { Shrapnel . . . ,,	121 8	85 10	60 5		..	60 5			51 7	37 14	
Carcasses . . . ,,	..	..	53 0		103	53 0			..	30 8	
Bursting charge { Common . . . ,,	6 14	3 13	2 9		6 12	2 9			2 7	1 12	
Bursting charge { Naval . . . ,,					6 5						
Bursting charge { Shrapnel . . drs.	128	96	80		..	80			70	60	
			aN C		N C	N C			C	C	
Fuzes { Percussion { L.S. . . .	..	..	..	1e	1e	..	1e	..	1e	1e	..
Fuzes { Pettman's { S.S.h . . .	1	1	1	..	1	..	1	..	..	..	..
Fuzes { Time, Boxer, Wood { Common . .	..	..	..	1	1	..	1	..	1	1	..
Fuzes { Time, Boxer, Wood { Diaph. Shrapnel } .	1	1	..	1	..	..	1	..	1	1	..

a N, Naval. C, Common. b Dundas's. c Millar's. d Monk's A, B, C. e If the shell plugs have a cross on them, not otherwise.
f The 8 lbs. charge is to be used with 10" carcasses. g Charges for hot shot for 42-Prs. of 84 cwt., 10 lbs. 8 ozs.
h Pettman's S.S. fuzes, and the 20" and 7½" metal time fuze, will be superseded by Pettman's general service and 20" and 9" M.L. wood time fuzes, as soon as a sufficient store has been made.
N.B.—*Those natures marked with ○ are only retained in the service until the few pieces still existing are used up or replaced.*

LIST OF SERVICE GUNS, AND AMMUNITION—*continued.*

		SMOOTH-BORE GUNS—*continued.* Cast-iron. 32-Pounder.											24-Pounder.			
Weight	cwt.	63°[e]	58[b]	56[d]	50[e] A	48 or 50°[c]	45[e] B	42[e] C	40[f]	39[f]	32[f]	25[b]	50[d]	48[d]	20[f] or 22	..
Length	ft. in.	9 7	9 6	9 6	9 0	8 0	8 6	8 0	7 6	7 6	6 6	6 0	9 6	9 0	6 0	..
Calibre	in.	6·41	6·375	6·41	6·375	6·41	6·35	6·35	6·35	6·35	6·3	6·3	5·823	5·823	5·823	..
Charge: Battering	lb. oz.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Charge: Service	,,	10[h]	10[h]	10[h]	8	8	7	6	6	6	5	4 0	8[i]	8[i]	2 8	..
Charge: Saluting or Exercising	,,	6	6	6	4	4	4	4	4	4	3	2 8	5	5	2 8	..
Shot: Solid	lb. oz.	..	..	..	..	..	31 6	..	..	..	..		..	23 8	..	..
Shot: Steel	,,	..	..	..	..	..	..	..	..	..	..		..	..	..	..
Shot: Grape	,,	..	..	..	..	..	37 8½	..	..	..	..	..	..	26 3	..	..
Shot: Case	,,	..	..	..	..	O.P. N.P.	34 11 36 12	..	..	..	..	..	..	24 2	..	..
Shell: Common, empty	,,	..	..	..	..	..	22 5	..	..	..	..	..	..	16 12	..	..
Shell: Naval	,,	..	..	..	..	..	22 6	..	..	..	..	..	..	..	..	..
Shell: Shrapnel	,,	..	..	..	..	..	28 3½	..	..	..	..	..	..	21 5	..	..
Carcasses	,,	..	..	..	..	..	28 8	..	..	..	..	..	..	18 0	..	..
Bursting charge: Common, Naval	,,	..	..	..	..	..	1 5	..	..	..	..	..	..	1	..	..
Bursting charge: Shrapnel	drs.	..	..	..	..	..	50	..	..	..	..	..	..	40	..	..
						N[a]	C									
Fuzes: Percussion L.S.		..	..	..	..	..	1[g]	..	..	..	..	..	1[g]	1[g]	1[g]	1[g]
Fuzes: Pettman's S.S.[k]		..	..	..	..	1	..	..	..	..	..	..	..	..	..	..
Fuzes: Time, Boxer, Wood: Common		..	..	..	..	..	1	..	..	..	..	..	1	1	1	..
Fuzes: Time, Boxer, Wood: Diaph., Shrapnel		..	..	..	..	..	1	..	..	..	..	..	1	1	1	..

[a] N, Naval. C, Common. [b] Dundas's. [c] Millar's. [d] Blomefield's. [e] Monk's A, B, C. [f] Bored-up.

[g] If the shell plugs have a cross on them, not otherwise. [h] Charges for hot shot for 32-Prs. 63 to 56 cwt., 7 lbs. 8 ozs.

[i] Charges for hot shot for 24-Prs. of 50 and 48 cwt., 6 lbs.

[k] Pettman's S.S. fuzes, and the 20″ and 7½″ metal time fuze, will be superseded by Pettman's general service and 20″ and 9″ M. L. wood time fuzes, as soon as a sufficient store has been made.

N.B.—*Those natures marked with ° are only retained in the service until the few pieces still existing are used up or replaced.*

		Cast-iron.									Cast-iron Howitzers.		
		18-Pounder.				12-Pounder.		9-Pounder.		6-Pr.	10-in.	8-in.	5½ in.°
Weight	cwt.	42[b]	38[b]	20[c]	15[c]	34[b]	33[b]	28[b]	24[b] or 25	17[b]	42[a]	22[a]	16
Length	ft. in.	9 0	8 0	6 0	5 6	9 0	8 6	8 6	7 0	6 0	5 0	4 0	3 4
Calibre	in.	5·292	5·292	5·17	5·17	4·623	4·623	4·2	4·2	3·668	10	8	5·68
Charge: Battering	lb. oz.	..	..	..	..	..	..	..	..	..	..	..	..
Charge: Service	,,	6[e]	6[e]	3	2	..	..	..	..	..	7	4	2
Charge: Saluting or Exercising	,,	4	4	3	2	..	..	..	.	..	4	3	2
Shot: Solid	lb. oz.	..	..	17 12	..	12 4	12 4	9 2	9 2	6 0	..	..	..
Shot: Steel	,,	..	..	..	..	..	..	..	..	..	..	..	..
Shot: Grape	,,	..	..	18 14	..	12 12	12 12	10 7	10 7	6 9½	..	..	..
Shot: Case	,,	..	..	19 3	..	16 12	16 12	13 6	13 6	8 12	89 7	31	13 13
Shell: Common, empty	,,	..	..	12 10	..	8 9	8 9	..	..	..	79 4	47 4	16 11
Shell: Naval	,,	..	..	..	..	..	..	..	..	..	..	..	..
Shell: Shrapnel	drs.	..	..	15 15	..	10 3	10 3	7 13	7 13	5 0½	..	..	..
Carcass e	,,	..	..	14 2	..	9 1	9 1	..	..	..	..	..	..
Bursting charge: Common, Naval	,,	..	..	0 12	..	0 7	0 7	..	..	..	6 12	2 9	1 0
Bursting charge: Shrapnel	drs.	..	..	30	..	24	24	18	18	10	..	..	..
Fuzes: Percussion L.S.		1[d]	1[d]	1[d]	1[d]	1[d]	1[d]	..	..	..	1	1	1
Fuzes: Pettman's S.S.[f]		..	..	..	..	..	..	..	..	..	..	..	..
Fuzes: Time, Boxer, Wood: Common		1	1	1	1	1	1	..	..	..	1	1	1
Fuzes: Time, Boxer, Wood: Diaph., Shrapnel		1	1	1	1	1	1	1	1	1	1	1	1

[a] Millar's. [b] Blomefield's. [c] Bored-up. [d] If the shell plugs have a cross on them, not otherwise.

[e] Charges for hot shot for 18-Prs. of 42 and 38 cwt., 4 lbs. 8 ozs.

[f] Pettman's S. S. fuzes, and the 20″ and 7½″ metal time fuze, will be superseded by Pettman's general service and 20″ and 9″ M.L. wood time fuzes, as soon as a sufficient store has been made.

N.B.—*Those natures marked with ° are only retained in the service until the few pieces still existing are used up or replaced.*

WEIGHTS, AND TONNAGE OF THE VARIOUS NATURES OF CARRIAGES, WAGGONS, ETC.,* MANUFACTURED IN THE ROYAL CARRIAGE DEPARTMENT

CARRIAGES TRAVELLING WITH WHEELS.

FOR IRON ORDNANCE.

			Weight.			Total Weight.			Tonnage.	
Guns.			cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	tons.	ft.
8 In. 54 Cwt.	Bracket	Carriage	28	2	0	40	2	23	6	0
		Limber	10	0	0					
		Side Arms, incl. Trail Box	2	0	23					
	Block	Carriage	27	0	0	39	3	6	7	6
		Limber	10	2	0					
		Side Arms	2	1	6					
32 Pr. 50 Cwt.	Bracket	Carriage	25	0	0	37	0	18	6	0
		Limber	10	0	0					
		Side Arms, incl. Trail Box	2	0	18					
	Block	Carriage	26	0	0	38	3	0	7	6
		Limber	10	2	0					
		Side Arms	2	1	0					
24 Pr. 50 Cwt.	Bracket	Carriage	24	2	0	36	2	17	6	0
		Limber	10	0	0					
		Side Arms, incl. Trail Box	2	0	17					
	Block	Carriage	25	3	0	38	2	0	7	0
		Limber	10	2	0					
		Side Arms	2	1	0					
18 Pr., 38½ Cwt. Block		Carriage	24	1	0	38	1	25	6	16
		Limber with Boxes, &c.	12	0	0					
		Side Arms	2	0	25					
Mortars.										
13 In., 36 Cwt.		Carriage	46	3	0	59	0	14	7	10
		Limber	10	2	0					
		Side Arms	1	3	14					
10 In., 18 Cwt.		Carriage	18	2	0	28	1	24	4	6
		Limber Cart	8	2	0					
		Side Arms	1	1	24					
8 In., 9 Cwt.		Carriage	12	0	0	20	3	0	3	28
		Limber Cart	8	2	0					
		Side Arms	0	1	0					

* *Exclusive of* Gun, Ammunition, and Laboratory Stores.

CARRIAGES TRAVELLING WITH WHEELS—*continued.*

FOR IRON ORDNANCE—*continued.*

		Weight.	Total Weight.	Tonnage.
Howitzers, Smooth Bore.		cwt. qrs. lbs.	cwt. qrs. lbs.	tons. ft.
10 In., 41 Cwt.	Carriage	31 3 0	42 1 18	6 17
	Limber	10 0 0		
	Side Arms, incl. Trail Box	0 2 18		
8 In., 21 Cwt.	Carriage	24 0 0	34 2 0	5 37
	Limber	10 0 0		
	Side Arms, incl. Trail Box	0 2 0		
Guns, Rifled.				
64 Pr.	Carriage	27 0 0	39 3 14	7 6
	Limber	10 2 0		
	Side Arms	2 1 14		
40 Pr.	Carriages	28 0 0	42 2 18	6 16
	Limber with Boxes	12 1 0		
	Side Arms	2 1 18		
20 Pr.	Carriage	16 0 0	28 3 8	5 8
	Limber with Boxes	11 2 0		
	Side Arms	1 1 8		
12 Pr.	Carriages	12 0 0	23 3 6	4 20
	Limber with Boxes	10 3 0		
	Side Arms	1 0 6		
9 Pr.	Carriage	10 1 0	22 0 4	4 20
	Limber with Boxes	10 3 0		
	Side Arms	1 0 4		
6 Pr. Colonial or Service	Carriage	5 3 0	11 3 6	2 28
	Limber with Boxes	5 1 0		
	Side Arms	0 3 6		
6 Pr. Kaffraria Pattern	Carriage	7 1 0	16 0 6	4 6
	Limber with Boxes	8 0 0		
	Side Arms	0 3 6		

FOR BRONZE ORDNANCE, SMOOTH BORE.

		Weight.	Total Weight.	Tonnage.
Guns.				
12 Pr.	Carriage	13 0 0	25 1 18	5 33
	Limber with Boxes	11 1 0		
	Side Arms	1 0 18		

NOTE.—On active service, each Field Battery is accompanied by 1 spare Carriage and Limber, the latter being fitted with 1 long box for spare Ironwork, excepting the *6 Pr. rifled* and *3 Pr. smooth-bore* Colonial, which have the service boxes for Ironwork.

Two spare Axletrees are carried under the Carriage.

CARRIAGES TRAVELLING WITH WHEELS—*continued.*

FOR BRONZE ORDNANCE, SMOOTH BORE—*continued.*

			Weight.			Total Weight.			Tonnage.	
Guns—*continued.*			cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	tons.	ft.
9 Pr.		Carriage	12	0	0	23	2	14	5	1
		Limber with Boxes	10	2	0					
		Side Arms	1	0	14					
FOR BRONZE ORDNANCE.										
Guns, Smooth Bore.										
6 Pr.		Carriage	10	1	0	21	3	8	4	21
		Limber with Boxes	10	2	0					
		Side Arms	1	0	8					
3 Pr.	3 Cwt. Colonial	Carriage	4	1	0	8	2	10	1	37
		Limber with Boxes	4	0	0					
		Side Arms	0	1	10					
	2½ Cwt. China Pattern	Carriage	2	0	18	2	2	26	0	29
		Shafts	0	1	16					
		Side Arms	0	0	20					
Howitzers, Smooth Bore.										
32 Pr.		Carriage	14	2	0	27	0	3	5	29
		Limber with Boxes	11	1	0					
		Side Arms	1	1	3					
24 Pr.		Carriage	14	0	0	25	2	11	5	6
		Limber with Boxes	10	2	0					
		Side Arms	1	0	11					
12 Pr.		Carriage	11	1	0	22	3	4	4	21
		Limber with Boxes	10	2	0					
		Side Arms	1	0	4					
4⅖ In.	Colonial	Carriage	5	2	0	9	3	12	1	37
		Limber with Boxes.	4	0	0					
		Side Arms	0	1	12					
	Gambia Pattern	Carriage	3	3	0	8	0	0	1	34
		Limber with Boxes	4	0	0					
		Side Arms	0	1	0					
	China Pattern	Carriage	2	1	14	2	3	18	0	30
		Shafts	0	1	16					
		Side Arms, incl. Bearers	0	0	16					
	Mountain Service	Carriage	2	2	12	3	0	16	0	31
		Shafts	0	1	16					
		Side Arms, incl. Bearers	0	0	16					

CARRIAGES TRAVELLING WITH WHEELS—*continued.*

FOR BRONZE ORDNANCE—*continued.*

			Weight.	Total Weight.	Tonnage.
HOWITZERS, RIFLED.			cwt. qrs. lbs.	cwt. qrs. lbs.	tons. ft.
...r. .	India 1865 Pattern	Carriage . .	2 2 9	3 0 1	0 24
		Shafts . . .	0 1 16		
		Side Arms, incl. Bearers . .	0 0 20		

WAGGONS.

AMMUNITION, WITH BOXES, WHEELS, ETC.

			Weight.	Total Weight.	Tonnage.
RIFLED.					
...Pr. . .		Body	14 0 0	28 1 19	6 20
		Limber	10 3 0		
		Side Arms . . .	1 1 7		
		Spare Wheel, 2nd Class, heavy.	2 1 12		
...Pr.* . .		as 40 Pr. . . .	..	28 1 19	6 20
... and 9* Pr.		Body, Limber and Side Arms .	26 0 7	28 0 2	6 20
		Spare Wheel, 2nd Class, light .	1 3 23		
...	Colonial or Service	Body . . .	7 3 0	15 0 3	2 24
		Limber . . .	5 1 0		
		Side Arms . .	0 3 3		
		Spare Wheel, 3rd Class, Gen. Serv., 4ft. 2in.	1 1 0		
	Kaffraria Pattern	Body . . .	10 3 0	21 2 21	5 0
		Limber . . .	8 0 0		
		Side Arms . .	1 1 7		
		Spare Wheel, 3rd Class, 5ft. diameter . .	1 2 14		
SMOOTH BORE.					
...12, and 9 ... Gun. 32 ... 24 Pr. ...witzer .		Body	11 1 0	25 1 19	6 0
		Limber	10 2 0		
		Side Arms . . .	1 1 7		
		Spare Wheel, 2nd Class, heavy .	2 1 12		

...e Spare Wheels *carried on the perches of the first line of* Ammunition ...ns *for 40 and 20 Pr. rifled, 18, 12,* and 9 Pr. Gun, 32 and 24 Pr. Howitzer ...*bore Field Batteries are second* class, and divided into equal Nos. of ...*d light.*

WAGGONS—*continued.*

AMMUNITION, WITH BOXES, WHEELS, ETC.—*continued.*

Smooth Bore—*continued.*		Weight. cwt.	qrs.	lbs.	Total Weight. cwt.	qrs.	lbs.	Tonnage. tons.	ft.
6 Pr. Gun and 12 Pr. Howitzer	Body	11	0	0	24	2	2	5	36
	Limber	10	1	0					
	Side Arms	1	1	7					
	Spare Wheel, 2nd Class, light	1	3	23					
3 Pr. Gun, and 4⅖ inch Howitzer Colonial	Body	4	3	0	10	3	3	2	22
	Limber	4	0	0					
	Side Arms	0	3	3					
	Spare Wheel, 3rd Class, General Service, 4ft. 2in.	1	1	0					
4⅖ in. Howitzer, Gambia Pattern	Body	4	0	0	9	2	10	2	23
	Limber	4	0	0					
	Side Arms	0	3	3					
	Spare Wheel	0	3	7					
Small Arm	Body	10	1	0	23	1	2	4	36
	Limber with Box	10	0	0					
	Side Arms	1	1	7					
	Spare Wheel	1	3	23					
Forge, Royal Artillery	Body	9	1	0	26	1	0	5	35
	Frame with Bellows, Anvil, Boxes, Hoops, and Cover	6	3	0					
	Limber with Box	10	1	0					
Store, Royal Artillery, N. P.	Body with internal fittings	16	1	0	26	2	7	8	19
	Limber with Box	10	0	0					
	Side Arms	0	1	7					
Store, Royal Artillery, O. P.	Body	12	1	0	22	3	7	5	11
	Limber with Box	10	1	0					
	Side Arms	0	1	7					
Ambulance	Body	14	1	0	16	2	0	5	20
	Stretchers, &c.	2	1	0					
Bread and Meat converted from Ambulance		..			17	2	0	6	19
Cooking	Boiler	..			26	1	0	6	37
	Pontoon	..			26	2	0	7	7
Corrugated-iron		..			16	3	0	4	5
Flanders		..			16	2	0	5	0
Forge	*Royal Engineers*	..			34	0	0	7	10
	Military Train	..			23	0	0	4	10
General Service		16	2	0	17	3	0	3	21
Spare Wheel		1	1	0					

WAGGONS—*continued.*

AMMUNITION WITH BOXES, WHEELS, ETC.—*continued.*

	Weight.			Total Weight.			Tonnage.	
	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	tons.	ft.
General Service Siege Train for Shot and Shell	20	3	0	22	1	26	3	31
Spare Wheel	1	2	26					
Platform — Gun or Mortar	..			22	0	0	3	16
Platform — 40 Pr. Battery	..			23	1	0	3	22
Miners	..			19	2	0	..	
Pontoon — Heavy or Cavalry	47	3	0	47	3	0	16	25
Pontoon — Light or Infantry	..			26	0	0	12	26
Sling — Iron 12 ton Gun — Body	65	1	0	76	2	0	13	15
Sling — Iron 12 ton Gun — Limber	11	1	0					
Sling — Wood — 23 ton Gun — Body	125	3	0	148	1	0	22	13
Sling — Wood — 23 ton Gun — Limber	22	2	0					
Sling — Wood — Service — Body	25	1	0	36	1	0	8	11
Sling — Wood — Service — Limber	11	0	0					
Telegraph complete	..			25	0	0	8	23

CARTS.

	Weight.	Total Weight. cwt.	qrs.	lbs.	Tonnage. tons.	ft.
Ammunition with fixed sides	..	6	2	0	3	23
Forage	..	7	3	0	2	8
Forge — Common	..	12	0	0	3	9
Forge — Royal Engineers	..	14	0	0	3	13
Gibraltar — Large	..	11	2	0	4	33
Gibraltar — Small	..	10	2	0	4	1
Hand. — Common	..	4	3	0	1	10
Hand. — Altered from Forage	..	6	0	0	2	0
Maltese — Ambulance with Cots.	..	5	2	0	2	1
Maltese — Common	..	4	0	0	1	30
Medical Store	..	8	1	0	2	14
Royal Engineers	..	9	1	0	2	7
Sling	..	18	0	0	3	38
Store	..	11	3	0	3	16
Trench	..	7	0	0	1	23
West India	..	7	2	0	3	4
Water	..	7	0	0	4	0

PLATFORMS.

	Weight.	Total Weight. cwt.	qrs.	lbs.	Tonnage. tons.	ft.
Common for Permanent Works — Gun — 15 ft. by 10 ft.	..	29	2	0	1	19
Common for Permanent Works — Gun — 18 ft. by 10 ft.	..	35	0	0	1	30
Common for Permanent Works — Mortar — 13 in. 12 ft. by 12 ft.	..	26	3	0	1	14
Common for Permanent Works — *Mortar* — *10 in. and 8 in. 9 ft. by 9 ft.*	..	16	3	0	0	34

CARTS—*continued.*

PLATFORMS—*continued.*

	Weight.	Total Weight.	Tonnage.
	cwt. qrs. lbs.	cwt. qrs. lbs.	tons. ft.
Deck, Octagonal, 13 In. Mortar	..	58 2 0	4 10
Siege, Alderson's, Gun, 18 ft. by 10 ft.	..	24 0 0	1 32
Siege, Alderson's, Mortar, 13 In. 10ft. by 10ft.	..	19 2 0	1 28
Siege, Alderson's, Mortar, 10 In. 10ft. by 10ft.	..	10 0 0	0 30
Siege, Clerk's, 17 ft.	..	13 3 0	1 0
Siege, Common Gun, 16 ft. by 10 ft.	..	14 0 0	1 17
Siege, Pasley's, Gun, 15 ft. by 10½ ft.	..	13 3 0	1 17
Siege, Pasley's, Mortar, 7½ ft. by 6½ ft.	..	10 0 0 9 1 0	31 0 36 0
Casemate, 10 in. 68 Pr., and 8 in. Smooth Bore, 7 in. and 40 Pr. Rifled	..	27 0 0	2 10
Dwarf, from 112 to 42 cwt. Guns, also 8 In. Howitzer, Smooth Bore, 7 In. 64 and 40 Prs. Rifled	..	33 3 0	2 20
BEDS, MORTAR.			
Iron Land Service with coins, 13 Inch	..	32 3 0	1 9
Iron Land Service with coins, 10 Inch	..	17 3 0	0 22
Iron Land Service with coins, 8 Inch	..	8 3 0	0 12
Wood, 13 Inch Land and Sea Service, Bed	60 3 0	64 2 0	3 34
Wood, 13 Inch Land and Sea Service, Pintail	3 3 0		
Wood, 5½ Inch	..	1 0 0	0 5
Wood, 4⅖ Inch	..	0 3 0	0 2
MISCELLANEOUS.			
Capstan Crab	..	4 0 0	0 31
Carriages, Drag, Large, Removing Guns, 12 to 23 tons	..	61 0 0	7 10
Carriages, Drag, Large, Removing Guns, 5 tons	..	16 1 0	1 33
Carriages, Drag, Large, Removing Guns, Small	..	5 3 0	0 29
Carriages, Drag, Large, Service	..	17 2 0	2 7
Carriages, Drag, Medium	..	10 2 0	2 1
Carriages, Drag, West India	..	5 0 0	0 24
Gyns, Bell's	5 0 0	5 0 0	0 35
Gyns, Gibraltar	..	14 3 0	1 29
Gyns, Triangle, 18 Feet	..	13 2 0	1 23
Gyns, Triangle, Ditto to lift 12 tons	..	24 1 0	2 7
Gyns, Triangle, 16 Feet	..	9 0 0	1 9
Deck, Octagonal	..	54 2 0	2 30
Forge, Portable, and Pack Saddle *in Wood Case*	..	2 1 0	0 17

CARTS—*continued.*

MISCELLANEOUS—*continued.*

	Weight.			Total Weight.			Tonnage.	
	cwt.	qrs.	lb.	cwt.	qrs.	lbs.	tons.	ft.
For Transporting Wood Platform, Axletree with Wheels	3	3	25	6	1	13	1	16
For Transporting Wood Platform, Limber	2	1	16					
For Transporting Wrought Iron Platforms for Heavy Guns, Up to 12 Tons, Axletree with Wheels	12	0	0	20	0	0	4	15
For Transporting Wrought Iron Platforms for Heavy Guns, Up to 12 Tons, Limber	8	0	0					
For Transporting Wrought Iron Platforms for Heavy Guns, Above 12 Tons, Axletree with Wheels	12	1	0	20	1	0	4	15
For Transporting Wrought Iron Platforms for Heavy Guns, Above 12 Tons, Limber	8	0	0					

CARRIAGES, GARRISON.

	Weight.	Total Weight.			Tonnage.	
SLIDING, CASEMATE PLATFORMS.						
Rifled . . 7 Inch	..	15	2	0	1	30
Rifled . . 40 Pr.	..	12	2	0	1	20
Smooth Bore 68 Pr.	..	15	0	0	1	33
Smooth Bore 10 Inch	..	15	0	0	1	33
Smooth Bore 8 Inch, 65 Cwt. .	..	14	0	0	1	24
SLIDING FOR DWARF PLATFORMS.						
Rifled . . 7 Inch Heavy .	..	16	2	0	1	38
Rifled . . 7 Inch Light .	..	15	3	0	1	36
Rifled . . 64 Pr.	..	13	2	0	1	34
Rifled . . 40 Pr.	..	13	0	0	1	28
Smooth Bore, 68 Pr. . 112 Cwt.	..	16	1	0	1	36
Smooth Bore, 68 Pr. . 95 Cwt.	..	15	2	0	1	34
56 Pr., 98 Cwt.	..	15	3	0	1	35
42 Pr., 84 Cwt.	..	15	1	0	1	33
10 Inch.	..	15	2	0	1	34
8 Inch. . 65 Cwt. . . .	..	14	3	0	1	25
8 Inch. . 54 Cwt. . . .	..	14	0	0	1	22
32 Pr. . . 63 Cwt. . . .	..	14	2	0	1	25
32 Pr. . . 58, or 56 Cwt.. .	..	14	0	0	1	22
32 Pr. . . 50 Cwt. . . .	..	13	0	0	1	20
24 Pr., 50 Cwt.	..	12	3	0	1	19
18 Pr., 42, or 38 Cwt.	..	11	0	0	1	18
Howitzers . *10 Inch, 42 Cwt.* .	..	14	1	0	1	18
Howitzers . *8 Inch, 22 Cwt.* .	..	12	3	0	1	5

CARRIAGES, GARRISON—*continued.*

COMMON FOR TRAVERSING PLATFORMS.	Weight. cwt. qrs. lbs.	Total Weight. cwt.	qrs.	lbs.	Tonnage. tons.	ft.
8 Inch, 65 Cwt.	..	14	3	0	2	0
32 Pr., 56 Cwt.	..	14	3	0	1	38
24 Pr., 50, or 48 Cwt.	..	13	3	0	1	36
18 Pr., 42 Cwt.	..	12	3	0	1	32
Howitzer — 10 Inch, 42 Cwt.	..	15	0	0	1	35
Howitzer — 8 Inch, 22 Cwt.	..	13	0	0	1	33
REAR CHOCK.						
Rifled — 7 Inch	..	19	0	0	2	0
Rifled — 64 Pr.	..	13	1	0	1	36
Smooth Bore — 68 Pr., 95 Cwt.	..	19	1	0	2	6
Smooth Bore — 10 Inch	..	19	1	0	2	6
Smooth Bore — 8 Inch — 65 Cwt.	..	15	0	0	1	37
Smooth Bore — 8 Inch — 54 Cwt.	..	14	2	0	1	36
Smooth Bore — 24 Pr., 20 Cwt.	..	8	2	0	1	10
Smooth Bore — Howitzer — 10 In., 42 Cwt.	..	15	0	0	1	35
Smooth Bore — Howitzer — 8 In., 22 Cwt.	..	13	0	0	1	33
Smooth Bore — Howitzer — 5½ Inch	..	7	2	0	0	31
COMMON STANDING.						
Wood — Rifled — 64 Pr.	..	14	1	0	1	37
Wood — Rifled — 40 Pr.	..	13	3	0	1	31
Wood — Rifled — Ditto from Recoil Carriage	..	23	1	0	2	38
Wood — Smooth Bore — 8 Inch, 65 Cwt.	..	14	3	0	2	0
Wood — Smooth Bore — 42 Pr., 67 Cwt.	..	14	3	0	1	39
Wood — Smooth Bore — 32 Pr. — 63 Cwt.	..	14	3	0	1	39
Wood — Smooth Bore — 32 Pr. — 58, or 56 Cwt.	..	14	2	0	1	38
Wood — Smooth Bore — 32 Pr. — 50 Cwt.	..	14	0	0	1	37
Wood — Smooth Bore — 32 Pr. — 42 Cwt.	..	13	1	0	1	32
Wood — Smooth Bore — 24 Pr. — 50 Cwt.	..	13	3	0	1	36
Wood — Smooth Bore — 24 Pr. — 20 Cwt.	..	8	0	0	1	1
Wood — Smooth Bore — 18 Pr.	..	12	3	0	1	32
Wood — Smooth Bore — 12 Pr.	..	11	2	0	1	11
Wood — Smooth Bore — 9 Pr.	..	10	2	0	1	1
Wood — Smooth Bore — 6 Pr.	..	9	1	0	0	38
Wrought Iron — 64 Pr. Rifled, 8 Inch, 65 and 54 Cwt., Smooth Bore	..	17	1	0	1	10
Wrought Iron — *40 Pr. Rifled, 32 Pr., 58 and 56 Cwt. Guns, Smooth Bore*	..	17	2	0	1	10

CARRIAGES, NAVAL.

SLIDING.

	Weight.	Total Weight.	Tonnage.
	cwt. qrs. lbs.	cwt. qrs. lbs.	tons. ft.
Wood, Rifled, 7 Inch	..	15 3 0	1 27
Wood, Rifled, 40 Pr.	..	14 0 0	1 22
Wood, Rifled, 64 Pr.	..	14 1 0	1 26
Wood, Smooth Bore, 150 Pr.	..	36 2 0	2 30
Wood, Smooth Bore, 100 Pr.	..	22 2 0	1 36
Wood, Smooth Bore, 68 Pr., 95 Cwt.	..	18 2 0	1 28
Wood, Smooth Bore, 10 Inch, 87 Cwt.	..	12 1 0	1 26
Wood, Smooth Bore, 8 Inch, 65 Cwt.	..	13 3 0	1 21
Wood, Smooth Bore, 8 Inch, 54 Cwt.	..	9 1 0	1 18
Smooth Bore, 32 Pr., 58, or 56 Cwt.	..	11 3 0	1 20
Smooth Bore, 32 Pr., 50, or 45 Cwt.	..	9 3 0	1 8
Smooth Bore, 32 Pr., 42 Cwt.	..	8 0 0	0 36
Smooth Bore, 32 Pr., 32 Cwt.	..	6 0 0	0 29
Smooth Bore, 32 Pr., 25 Cwt.	..	5 0 0	0 27

REAR CHOCK.

	Weight.	Total Weight.	Tonnage.
Rifled, 7 Inch	..	12 0 0	1 36
Rifled, 20 Pr.	..	4 2 0	0 34
Smooth Bore, 68 Pr.	..	13 3 0	2 0
Smooth Bore, 10 Inch	..	13 3 0	2 0
Smooth Bore, 32 Pr., 25 Cwt.	..	4 3 0	1 0
Smooth Bore, Howitzer, 24 Pr.	..	4 1 0	0 33
Smooth Bore, 9 Pr. Brass	..	2 0 0	0 15
Smooth Bore, 6 Pr. Brass	..	1 2 0	0 11

COMMON TRUCK.

	Weight.	Total Weight.	Tonnage.
Rifled, 64 Pr.	..	8 3 0	2 0
Rifled, 40 Pr., Screw	..	8 1 0	1 26
Rifled, 40 Pr., Wedge	..	6 2 0	1 21
Smooth Bore, 8 Inch, 65, or 60 Cwt.	..	9 1 0	2 0
Smooth Bore, 8 Inch, 54 Cwt.	..	8 1 0	1 29
Smooth Bore, 32 Pr., 58, or 56 Cwt.	..	9 0 0	1 35
Smooth Bore, 32 Pr., 50, or 45 Cwt.	..	8 0 0	1 23
Smooth Bore, 32 Pr., 42 Cwt.	..	7 2 0	1 17
Smooth Bore, 32 Pr., 32 Cwt.	..	6 0 0	1 10

HARDY'S, OR JAMMING WITH SLIDES.

	Weight.	Total Weight.	Tonnage.
32 Pr., 32 Cwt.	..	6 0 0	1 0
32 Pr., 25 Cwt.	..	5 1 0	0 33

CARRIAGES, NAVAL—*continued.*

TOP WITH UNDER.		Weight.	Total Weight.	Tonnage.
		cwt. qrs. lb.	cwt. qrs. lbs.	tons. ft.
Rifled, with self-acting compressors	12 Pr.	..	4 3 0	0 23
	9 Pr.	..	4 2 0	0 22
Rifled, Top with Under	20 Pr.	..	5 0 0	0 28
	12 Pr.	..	4 2 0	0 26
	9 Pr.	..	3 3 0	0 24
Rifled	6 Pr. Top with Bottom	..	3 1 0	0 25
Smooth Bore, Top with Under, Howitzer	24 Pr.	..	5 1 0	0 28
	12 Pr.	..	4 1 0	0 26
Smooth Bore	6 Pr. Top with Bottom	..	3 2 0	0 25
TRAVELLING.				
Rifled, 12 Pr.	Carriage	7 0 0	13 2 0	3 8
	Limber	6 0 0		
	Side Arms	0 2 0		
Rifled, 9 Pr.	Carriage	6 3 0	13 1 0	2 30
	Limber	6 0 0		
	Side Arms	0 2 0		
Rifled, 6 Pr.	Carriage	5 0 0	10 1 11	2 24
	Limber	5 0 0		
	Side Arms	0 1 11		
Smooth Bore, Howitzer, 12 Pr.	Carriage	6 3 0	12 1 13	3 3
	Limber	5 1 0		
	Side Arms	0 1 13		
Smooth Bore, 8 Inch Mortar	Carriage	10 1 0	16 2 2	2 37
	Limber	6 0 0		
	Side Arms	0 1 2		
SLIDES.		Length. ft. in.		
Heavy	150 Pr. Smooth Bore, or 9 Inch M.L.R.	14 0	37 0 0	3 0
	100 Pr. ditto, or 7 Inch ditto	12 0	24 2 0	2 17
	68 Pr., or 10 Inch and 7 Inch B.L.R.	14 0	26 2 0	2 34
		12 6	25 0 0	2 13
	64 Pr., M.L.R.	12 0	19 0 0	2 8
		10 6	15 3 0	1 38
Medium, 8 In., 65 to 54 Cwt., 32 Pr. 58 to 45 Cwt., 40 Pr. B.L.R.		12 0	15 1 0	1 19
		10 6	12 3 0	1 12
Light, 32 Pr. 42 to 25 Cwt.		12 0	12 2 0	1 1
		10 0	9 3 0	0 34
Boat	*12 Pr. B.L.R.*	7 6	3 0 9	0 8
	9 Pr. B.L.R.	6 10	2 3 20	0 7

RANGE, ELEVATION, ETC., OF BRONZE ORDNANCE.

SOLID SHOT.			COMMON CASE SHOT.		
Elevation.	12 Pr. 9 Pr. Long 6 Pr.	Light 12 P. Ditto 6 P. Heavy 3 P.	Elevation.	12 Pr. 9 Pr.	6 Pr.
degrees.	yards.	yards.	degrees.	yards.	yards.
P. B.	300	200	P. B.	150	100
¼	400	300	¼	175	125
½	500	400	½	200	150
¾	600	500	¾	225	175
1	700	600	1	250	200
1¼	775	650	1¼	275	225
1½	850	700	1½	300	250
1¾	925	750	1¾	325	275
2	1000	800	2	350	300
2¼	1050	850			
2½	1100	900			
2¾	1150	950			
3	1200	1000			
3¼	1250	1050			
3½	1300	1100			
3¾	1350	1150			
4	1400	1200			

24 Pr. Howitzer. Charge 2½ lb.					12 Pr. Howitzer. Charge 1½ lb.					5½ in. Howitzer. Heavy | Light. 2 lb. Charge 1 lb.		
Com. Shells.			C. Case.		Com. Shells.			C. Case.		Com. Shells.		
Elevation.	Fuze.*	Range.	Elevation.	Range.	Elevation.	Fuze.*	Range.	Elevation.	Range.	Elevation.	Range.	Range.
deg.	10ths	yds.	deg.	yds.	deg.	10ths	yds.	deg.	yds.	deg.	yds.	yds.
P. B.		250	P. B.	150	1	1	400	P. B.	100	P. B.	250	150
¼		300	¼	175	1¼	1½	450	¼	125	1	400	300
½		350	½	200	1½	2	500	½	150	2	550	450
¾		400	¾	225	1¾	2½	550	¾	175	3	700	600
1	1	450	1	250	2	3	600	1	200	4	850	750
1¼	1½	500	1¼	275	2¼	3½	650	1¼	225	5	975	850
1½	2	550	1½	300	2½	4	700	1½	250	6	1100	950
1¾	2½	600	1¾	325	2¾	4½	750	1¾	275	7	1225	1050
2	3	650	2	350	3	5	800	2	300	8	1350	1150
2¼	3½	700	2¼	375	3¼	5½	850			9	1450	1200
2½	4	750	2½	400	3½	6	900			10	1550	1250
2¾	4½	800			3¾	6½	950			11	1650	1300
3	5	850			4	7	1000			12	1750	1350
3¼	5½	900			4¼	7½	1025					
3½	6	950			4½	7¾	1050					
3¾	6½	1000			4¾	8	1075					
4	7	1025			5	8¼	1100					
					5¼	8½	1125					
					5½	8¾	1150					

* Fuze—Old pattern.

*Ranges, Elevation, &c., of 8-inch Howitzer.**

Common Shells.				Shrapnel Shells.		Ricochet firing.			
Charge.	Fuze.	Elevation.	Range.	Fuze.	Elevation.	Charge.	Elevation.	Range.	Fuze.
lb.	inches.	deg.	yards.	inches.	deg.	lb.	deg.	yards.	inches.
4	·3	2	450	..	..	..	..	..	..
	·4	2½	600	·3	2⅝	1	9·5	400	·85
	·52	3	750	·5	3½	1·5	6·	400	·8
	·65	3¾	900	·7	4½	1·5	9·	600	1·
	·8	4½	1050	·9	5⅝	2	6·25	600	·9
	·95	5⅝	1200	1·1	6⅞	2·5	5·5	600	·75
	1·1	6¼	1350	1·35	8¼	2	8·5	800	1·2
	1·3	7¼	1500	1·6	9¾	2·5	6·25	800	1·
	1·5	8¼	1650						
	1·75	9⅝	1800			1	34·5	1170	
	2·	10½	1950			2	34·5	2010	
	2·3	11¾	2100						
	2·6	13	2250			3	5	900	
	3·	14¾	2400			3	10	1200	
	3·4	15¾	2550			3	15	1930	
	3·9	17¼	2700						

32 *Pr. Bronze Howitzer.*

Range.	Common Case.	Common Shell.		Shrapnel Shell.		Range.	Common Case.	Common Shell.		Shrapnel Shell.	
Yards.	Elevation.	Elevation.	Fuze.	Elevation.	Fuze.	Yards.	Elevation.	Elevation.	Fuze.	Elevation.	Fuze.
200	P B					1150		4¾	·8	4¼	
300	1°					1200		4⅞	·9	4⅝	·8
400	2°	¾°	·2	P B		1250		5½	·9	5	
450		⅞°	·2	¼°	·2	1300	..	..	·9	5¼	·9
500		1°	·2	½°		1350	..	..	1·0	5⅝°	
550		1¼°	·3	1°		1400	..	..	1·0	6°	1·0
600		1⅜°	·3	1¼°		1450	..	..	1·1	6¼	
650		1½°	·3	1⅝°	·3	1500	—	7½	1·1	6⅝	
700		1¾°	·4	2°		1550			1·2	7°	
750		2°	·4	2¼°		1600			1·3	7¼	
800		2¼°	·5	2½°	·4	1650			1·4	7⅝°	
850		2½°	·5	2¾°		1700			1·5	8°	
900		2¾°	·6	3°	·5	1750			1·6		
950		3°	·6	3¼		1800	—	9½	1·7		
1000		3¼	·7	3½°	·6	1850			1·8		
1050		3⅝	·7	3¾°		1900			1·9		
1100		4	·8	4°	·7	2000			2·0		

* *Being withdrawn from the Service.*

Range, Elevation, &c., of Bronze Ordnance.

SHRAPNEL SHELLS.

12 Pr. — Shell filled 10 lb. 13¾ oz. Shell empty 5 lb. 10 oz. Number of Balls . . 63

Letter & Length of Fuze	Elevation.	Range from	Range to
in. 10ths.	deg.	yds.	yds.
B ·2	1⅜	660	960
C ·3	1⅞	820	1110
D ·4	2¼	960	1230
E ·5	2¾	1080	1340
·6	3¼	1195	1445
·7	3¾	1301	1545
·8	4⅜	1415	1645
·9	5⅛	1520	1740
1 ·	5¾	1620	1830
1 ·1	6⅜	1720	1920
1 ·2	7	1815	2005
1 ·3	7⅝	1905	2085
1 ·4	8¼	1990	2160
1 ·5	8⅞	2070	2230
1 ·6	9⅜	2140	2290
1 ·7	10	2200	2310

9 Pr. — Shell filled 8 lb. 1¼ oz. Shell empty 4 lb. 9¼ oz. Number of Balls . . 41

Letter & Length of Fuze.	Elevation.	Range from	Range to
in. 10ths.	deg	yds.	yds.
B ·2	1⅜	640	920
C ·3	1⅞	800	1060
D ·4	2¼	930	1180
E ·5	2¾	1050	1290
·6	3¼	1160	1390
·7	3½	1260	1480
·8	4⅜	1360	1570
·9	5⅛	1455	1655
1 ·	5¾	1550	1740
1 ·1	6⅜	1640	1820
1 ·2	7	1725	1895
1 ·3	7⅝	1805	1965
1 ·4	8¼	1885	2035
1 ·5	8¾	1960	2100
1 ·6	9⅜	2030	2160
1 ·7	10	2095	2215
1 ·8	10¼	2165	2275

Light 6 Pr. — Shell filled 5 lb. 7¼ oz. Shell empty 3 lb. 2 oz. Number of Balls . . 27

Letter & Length of Fuze.	Elevation.	Range from	Range to
in. 10ths.	deg.	yds.	yds.
	1	380	640
B ·2	1¼	570	800
C ·3	1⅝	720	930
D ·4	2¼	845	1045
E ·5	2⅞	955	1145
·6	3⅜	1060	1240
·7	4	1160	1330
·8	4⅝	1255	1415
·9	5¼	1345	1500
1 ·	5⅞	1430	1580
1 ·1	6⅜	1510	1655
1 ·2	7¼	1585	1725
1 ·3	7⅝	1655	1785
1 ·4	8¼	1720	1840
1 ·5	8⅞	1780	1890
1 ·6	9⅜	1835	1940
1 ·7	10¼	1885	1980
1 ·8	11	1953	2020

24 Pr. Howitzer. — S. filled 21 lb. 4 oz. S. empty 11 lb. 1 oz. No. of Balls . . 129

Letter & Length of Fuze.	Elevation.	Range.
in. 10ths.	deg.	yds.
·1	1	450
·1½	1¼	500
B ·2	1½	550
·2½	1¾	600
C ·3	2	650
·3½	2¼	700
D ·4	2½	750
·4½	2¾	800
E ·5	3	850
·5½	3¼	900
·6	3½	950
·6½	3¾	1000
·7	4	1050
·7½	4¼	1100
·8	4½	1125
·8½	4¾	1150
·9	5	1175
·9½	5¼	1200

12 Pr. Howitzer. — S. filled 10 lb. 13¾ oz. S. empty 5 lb. 10 oz. No. of Balls . . 63

Letter & Length of Fuze.	Elevation.	Range.
in. 10ths.	deg.	yds.
·1	1¼	450
·1½	1½	500
B ·2	1¾	550
·2½	2	600
C ·3	2¼	650
·3½	2½	700
D ·4	2¾	750
·4½	3	800
E ·5	3¼	850
·5½	3½	900
·6	3¾	950
·6½	4	1000
·7	4¼	1025
·7½	4½	1050
·7¾	4¾	1075
·8	5	1100
·8¼	5¼	1125
·8½	5½	1150
·8¾	5¾	1175
·9	6	1200

Ricochet Practice with Bronze Ordnance.

Range in yards.	Solid Shot.				Common Shells.									
	12 Pr. Gun.		9 Pr. Gun.		24 Pr. Howitzer. Shell, 16 lb.		12 Pr. Howitzer. Shell, 8 lb.		$5\frac{1}{2}$ in. Howitzer heavy. Shell, 16 lb.		$5\frac{1}{2}$ in. Mortar. Shell, 16 lb.		$4\frac{2}{5}$ in. Mortar. Shell, 8 lb.	
	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.
	oz.	deg.	oz.	deg.	lb. oz.	deg.	oz.	deg.	lb. oz.	deg.	oz.	deg.	oz.	deg.
					6	$7\frac{1}{2}$								
400					9	$4\frac{3}{4}$			12	5	8	$14\frac{1}{2}$	5	$14\frac{1}{2}$
			8	4					8	8				
	6	$6\frac{1}{2}$	7	5	8	9			12	7				
	5	7	6	$6\frac{1}{4}$	10	$7\frac{1}{2}$								
			5	$6\frac{3}{4}$	11	6			10	9				
500					12	$5\frac{1}{4}$			8	11				
					14	5								
			7	$6\frac{1}{2}$	9	$7\frac{3}{4}$	6	7						
600			6	$7\frac{1}{2}$	12	$6\frac{1}{2}$	8	6	1	$6\frac{3}{4}$				
			5	$9\frac{1}{2}$	1	$4\frac{3}{4}$	10	5	12	9				

Note.—**When Shot are fired from the 24 Pounder, and 12 Pounder Howitzers, the Elevation must be about half a degree more than when Shells are used.**

Range, Charge, Elevation, &c., of Iron Ordnance.

	Nature.	Weight.	Length.		Diameter of the bore.	Charge of powder.		Range in yards.						
								Point blank.	1°	2°	3°	4°	5°	6°
		cwt.	ft.	in.	in.	lbs.	oz.							
GUNS.	42 Pr.	85	10		9·60	14		400	940	1340	1620	1840	2050	2250
	32 Pr.	63	9	7	6·41	10	10½	380	760	1130	1455	1730	1950	2160
		56	9	6	6·41	10	10½	380	760	1130	1455	1730	1950	2160
		48	8		6·41	8		330	680	1015	1300	1540	1740	1840
		40	7	6	6·35	6		340	675	985	1260	1500	1700	1800
	*	32	6	6	6·3	5		330	670	945	1210	1450	1640	1730
	*	25	6		6·3	4		225	485	735	995	1260	1500	1630
		25	5	4	6·3	4		225	485	735	995	1260	1500	1630
	24 Pr.	50	9	6	5·82	8		360	755	1125	1417	1670	1850	2000
		48	9		5·82	8		360	755	1125	1417	1670	1850	2000
		40	7	6	5·82	8		340	730	1080	1377	1620	1800	1950
		33	6	6	5·82	6		260	530	805	1082	1350	1560	1760
	18 Pr.	42	9		5·29	6		360	730	1080	1377	1600	1780	1960
		38	8		5·29	6		340	710	1075	1347	1560	1730	1900
	12 Pr.	34	9		4·62	4		360	720	1075	1337	1540	1700	1850
		29	7	6	4·62	4		340	710	1040	1307	1500	1650	1800
	9 Pr.	26	7	6	4·2	3		330	685	1015	1278	1460	1600	1730
	6 Pr.	17	6		3·66	2		320	655	985	1238	1400	1520	1610
CARRONADES.	68 Pr.	36	5	4	8·05	5	10½	270	540	812	1042	1240	1420	1570
	42	22	4	6	6·84	3	8	240	515	810	983	1180	1350	1880
	32	17	4		6·25	2	10	235	485	705	905	1100	1260	1400
	24	13	3	9	5·68	2		225	435	650	826	1000	1150	1300
	18	10	3	4	5·16	1	8	220	430	620	787	950	1100	1250
	12	6	2	8	4·52	1		205	375	580	738	880	1000	1100

* Bored-up guns.

Range, &c., of Iron Ordnance.

SHRAPNEL SHELLS.

68 Pr. Carronade.		8 in. Howitzer.		24 Pr. Gun.		18 Pr. Gun.		
lb. oz. Charge . . 4 0 Shell filled . 61 4 ,, empty 32 2 No. of Balls 337		lb. oz. Charge . . 4 0 Shell filled . 61 13 ,, empty 32 2 No. of Balls 337		lb. oz. Charge . . 5 0 Shell filled . 21 5 ,, empty 11 0 No. of Balls 128		lb. oz. Charge . . 4 8 Shell filled . 15 11 ,, empty 8 6 No. of Balls 90		
Elevation.	Fuze.	Elevation.	Fuze.	Elevation.	Fuze.	Elevation.	Fuze.	Range.
degrees.	tenths.	degrees.	tenths.	degrees.	tenths.	degrees.	tenths.	yards.
2½	4	2¾	3½	1¼	2	1¼	2	650
3½	6	3	6	1¾	3½	2	4	900
5	8½	6	10	2½	5	3	5¾	1100

Range, Elevation, &c., of 12, 10, *and* 8 *inch Guns*, 32 *Pr. Carronade Gun*, *and* 10, *and* 8 *inch Iron Howitzers.*

Nature of Ordnance.	Length. feet.	Length. in.	Weight. cwt.	Weight. qrs.	Charge. lb.	Charge. oz.	Point Blank.	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°
							Elevation in degrees; Range in yards; Flight in seconds.															
12-in. Gun (Hollow Shot)	3	4	90	3	12		240	540	790	1020	1250	1400	1550									
10 Do. . . .(H.S.)	7	6	57	3	7		210	460	720	935	1160	1350	1500									
	8	4	62	1	8		250	570	810	1030	1230	1400										
	9	4	84		12		325	630	930	1200	1460	1700										
8 Do. . . .(H.S.)	6	8¼	50		7		210	320	570	830	1130	1300										
8 Do. . (Solid Shot)	8	6	60		9	7	340	640	960	1190	1300	1500										
8 Do.	9		65		10		300	580	940	1220	1480	1700	1880	2120	2290	2430	2510	2710	2930	2990	3140	3250
Time of Flight . .							¾″	2″	3″	4¼″	5½″	7″	8″	8¾″	9¾″	10½″	11¼″	12¼″	12¼″	13″	13½″	14″
Ditto (Hollow Shot)	9		65		12		370	700	1050	1230	1540	1700	1831	1980	2090	2310	2400	2510	2720	2830	2870	2220
Time of Flight . .							1″	2¼″	3″	4¼″	6″	6½″	7¾″	8″	8¾″	10″	10½″	11½″	12½″	13¼″	14″	15¼″
32 Pounder Carronade Gun	5		25		4		200	470	730	960												
10-inch iron Howitzer.	5		40		7				600			1200	1320		1500		1926		2078			
8-inch ditto . . .	4		21		4				450	730			975		1227		1505		1725			

The above Range for the 12, and 10 inch Guns are with hollow shot, weighing respectively 112 lb., and 84 lb. The 8 inch Gun carries either hollow shot, plugged, 48 lb.; or shell, 46 lb.

56 Pounder Gun, and 68 Pounder Gun.

Weight, Ranges, &c.

	Gun.	Shot.	Charge.	P B	1°	2°	3°	4°	5°	6°	8°	10°	12°	Above Plane.
	cwt.	lb.	lb.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	feet. in.
56 Pr.	98	S S	16	490	930	1310	1720	2000	2200	2400	2740	3040	3320	5
	87	S S	14	380	900	1310	1660	1940	2100	2310	2590	2940	3270	8
68 Pr.	112	S S	20	400	980	1400	1760	1980	2240	2480	2840	3130	3400	8
	95	S S	15	310	700	1070	1430	1710	1930	2130	2520	2890	3180	5 4
	95	Shell	16	350	850	1250	1560	1840	2100	2350	2690	3000	3300	5 4
	87	S S	14	300	680	1050	1360	1650	1900	2140	2490	2820	3150	8
	87	Shell	14	310	710	1030	1350	1610	1850	2090	2450	2800	3140	8

8 *Inch Gun.*

Length, 9 feet; Weight, 65 cwt.; Height of gun above the plane, 5 feet 7 inches.

Nature of shot.	Charge.	Elevation.	First graze.	Flight.	Second graze.	Extreme range.	Time of flight.	Number of grazes.
	lb.	Degrees.	Yards.	Sec.	Yards.	Yards.	Sec.	
Solid	10	P. B.	315	1″	901	3207	20″	23
	10	1°	660	2″	1006	2803	19″	18
	10	1½°	818	3″	1240	2433	16″	13
	9	P. B.	343	1″	776	2683	17″	12
	9	1°	615	2″	970	2483	15″	10

LONG RANGES.

Nature of Ordnance.	Weight.	Charge.	Shot, or shell.	Elevation.	Greatest range.
	cwt.	lb.		degrees.	yards.
68 Pr.	95	12	Eccentric hollow 8 inch shot.	24	6500
10-inch	112	15	Eccentric shot, 91 lb.	28	5735
68 Pr.	95	16	Common shell	27¼	5605

Table of Penetrations of the principal Pieces of Ordnance.

	Penetration of Gun-shot into Earth of medium tenacity.	Thickness of Parapet.
	feet.	feet.
Smooth Bore 6 Pr. . . .	3½ to 4	6
,, ,, 9 Pr. . . .	6½ to 7	9
,, ,, 12 Pr. . . .	8½ to 10	12
,, ,, 18, or 24 Pr. .	12 to 15	18 or 20

From the Newhaven Experiments in 1863.

	Charge.	Projectile.	Range.	Mean penetration.
	lbs.		yds.	ft. in.
Smooth Bore 32 Pr.	8	Solid shot	1,050	13
„ „ 68 Pr.	16	Solid shot	..	20
„ „ 8-inch Gun	8	Shell	..	11 5
„ „ 10 „ „	12	Shell	..	11
Armstrong 12 Pr.	1¼	Segment shell	..	4
„ 20 Pr.	2¼	Solid shot	..	10 10
„ 40 Pr.	5	Solid shot	..	14 9
„ 70 Pr.	9	Solid shot	..	14 3
„ 110 Pr.	12	Solid shot	..	21 3

The object fired at was a well-built parapet of clayey earth, thickness at top 25 feet.

RICOCHET FIRING.

1. When adopted in the field, the guns should seldom be elevated above 3 degrees, as the objects fired at are generally cavalry, and infantry, and the lower the angle the longer will the shot preserve its force, and have effect.

2. In the ricochet of a fortification of any kind, the elevation should seldom exceed 10 degrees to throw the shot over the parapet a little higher than the level of the battery; and, on the whole, the best elevation to enfilade a work is from 6 to 9 degrees, measured above the crest of the parapet with corresponding charges.

3. The charge, and elevation being known for any range, when the gun, and parapet are on the same level, the same charge, and elevation may be used so long as the difference of level does not exceed one-twentieth of the horizontal distance between them, the elevation being given by the tangent scale, and the gun laid at the parapet, whether above, or below its own level.

Ricochet Practice with Iron Ordnance.

Range in yards.	Round Shot.								Common Shell.					
	68 Pr. Carronade.*		24 Pr. Gun, 9 Feet.		18 Pr. Gun, 8 Feet.		12 Pr. Gun, 8¼ Feet.		10-inch Howitzer Shell, 92 lb.		8-inch Howitzer Shell, 46 lb.		24 Pr. Howitzer Shell, 16 lb.	
	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.
	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.
400			12	6¼	9	6¼	8	4½	2 8	6¼	1 8	6	9	4¾
			10	7¾			6	6¼	2	8½	1	9¾	6	7¼
			8	11										
600	1 12	7	6	6	1	5¼	12	4¾	3	6½	1 8	8¼	1	4¾
	1 8	8¾	1 8	4	12	7	10	6	2 8	8¼	1 4	10	12	5¼
			1	6½			8	7¾					9	7½
800			2	3¾	1 8	4¼	1	4½	4	6¼	2 8	6¼		
			1 8	5½	1	7	12	6½	3 8	7½	2	6½		

* **Note.—When Shells are fired from the 68 Pounder Carronade, the Elevation must be decreased about half a degree.**

MORTARS.

Practical rules.

To find the Charge for a given Range at 45° *elevation.*

13 *inch Mortar.*—To the range, in yards, add half the range, multiply the sum by ·03 for the charge, in ounces.

10 *inch Mortar.*—When the range is under 1350 yards, add to the range 160, and multiply by ·02 ; and if the range is over 1350 yards, add one-fifth of the range, and multiply by ·02 for the charge, in ounces.

8 *inch Mortar.*—To the range, in yards, add 20, and the sum multiplied by ·015 will give the charge, in ounces.

5½ *inch Mortar.*—To the range, in yards, add 150, and multiply by ·08, for the charge, in ounces.

4⅖ *inch Mortar.*—To the range, in yards, add 300, and multiply by ·06 for the charge, in drams.

To find the time of flight, the range being given. Divide the square root of the range, in feet, by 4·5 for the time of flight, in seconds.

To find the Range, the Time of flight being given. Multiply the time of flight, in seconds, by 4·5, and square the product for the range, in feet.

*To find the length of Fuze**, for a given range. Multiply the time of flight, in seconds, by ·22, for the 13, and 10-inch mortars, and by ·24 for 8, 5½, and 4⅖ *inch mortars*, for the length of fuze, in tenths.

* *Old pattern.*

Mortar Practice at 15°, 25°, and 45° Elevation. 1838.

13 INCH IRON.
Weight . . . 36 cwt.
*Shell filled . . 200 lb.
Burst. powder 6 lb. 12 oz.
Blowing powder 2 oz.

Elevation.	Charge.		Fuze.	Range.
degs.	lb.	oz.	in.	yds.
45	2	1½	1·9	450
	2	3	2·	500
	2	4¾	2·1	550
	2	6	2·2	600
	2	7¾	2·3	650
	2	9½	2·4	700
	2	11¾	2·45	750
	2	14	2·5	800
	3	½	2·55	850
	3	3	2·6	900
	3	5½	2·65	950
	3	8	2·7	1000
	3	10	2·75	1050
	3	12	2·8	1100
	3	14	2·85	1150
	4		2·9	1200
	4	5	3·	1300
	4	15	3·2	1500
	5	10	3·4	1700
†	9			2900

10 INCH IRON.
Weight . 16 cwt. 2 qrs.
Shell filled . . 92 lb.
Burst. powder 2 lb. 10 oz.
Blowing powder 1¼ oz.

Elevation.	Charge.		Fuze.	Range.
degs.	lb.	oz.	in.	yds.
45	1	½	1·9	450
	1	2	2·	500
	1	3¼	2·1	550
	1	4¾	2·2	600
	1	6	2·3	650
	1	7½	2·4	700
	1	9	2·45	750
	1	10	2·5	800
	1	11	2·55	850
	1	12	2·6	900
	1	13	2·65	950
	1	14	2·7	1000
	1	15¼	2·75	1050
	2	½	2·8	1100
	2	1¾	2·85	1150
	2	3	2·9	1200
†	4			2400

8 INCH IRON.
Weight . . 8 cwt. 1 qr.
Shell filled . . . 46 lb.
Burst. powder 1 lb. 14 oz.
Blowing powder . 1 oz.

Elevation.	Charge.		Fuze.	Range.
degs.	lb.	oz.	in.	yds.
15		14	·8	500
	1		1·	550
	1	2	1·1	600
45		9	1·9	450
		10¾	2·	500
		12½	2·1	550
		13¼	2·2	600
		14½	2·3	650
		15½	2·4	700
	1		2·45	750
	1	½	2·5	800
	1	1¼	2·55	850
	1	2	2·6	900
	1	2¾	2·65	950
	1	3½	2·7	1000
	1	4	2·75	1050
	1	4¾	2·8	1100
	1	5¼	2·85	1150
	1	6	2·9	1200
†	2			2000

5½ INCH BRASS.
Weight 1 cwt. 1 qr. 10 lb.
Shell filled . . 16 lb.
Burst. powder . 10 oz.
Blowing powder ¼ oz.

Elevation.	Charge.		Fuze.	Range.
degs.	oz.	drs.	in.	yds.
15	6		·7	350
	7		·75	400
	7	8	·8	450
	8		85	500
25	5	8	1·1	480
45	4	8		300
	4	12		350
	5		1·75	400
	5	4	1·8	450
	5	8	1·85	500
	5	12	1·9	550
	6		1·95	600

4⅔ INCH BRASS.
Weight 3 qrs. 19 lb.
Shell filled . 8 lb.
Burst. powder 5 oz.
Blowing powder ¼ oz.

Elevation.	Charge.		Fuze.	Range.
degs.	oz.	drs.	in.	yds.
15	4	8	·8	450
	4	12	·85	500
25	4		1·1	540
45	2	6	1·65	300
	2	9	1·7	350
	2	12	1·75	400
	3		1·8	450
	3	4	1·85	500
	3	8	1·9	550
	3	12	1·95	600

AMMUNITION, PROJECTILES, LABORATORY COMBUSTIBLES, STORES, ETC. ROCKETS, WAR.

CARTRIDGE, BALL; BOXER, SNIDER CONVERTED ENFIELD RIFLE.

Central fire in a case of rolled sheet brass, with paper cover; the ball has a clay plug in base, and wood plug in head.

Five patterns have been made, of which *four* are in the service.

Pattern 2.—White paper cover, brass base disc, bullet 4 cannelures filled and covered with wax. Intended for short rifles.

Pattern 3.—White cover, brass base disc, bullet 3 saw-shaped cannelures. Is for long rifles.

Pattern 4.—White cover, iron base disc, bullet 3 saw-shaped cannelures. Is for long rifles.

Pattern 5.—To supersede all others. Brown paper cover, iron base disc, bullet 4 saw-shaped cannelures. Is for all Snider rifles ·577 bore.

All patterns may be interchanged on an emergency, but the shooting may be less accurate.

A bundle of 10 cartridges (Pattern 5) weighs 15 or 13 drs. Each cartridge is waterproof, and it is nearly impossible to explode a barrel of this ammunition *en masse:* it may be blown violently in pieces, without igniting more than one or two cartridges.

CARTRIDGE, BLANK.

As Pattern 5 above, without bullet and paper cover. Slighter case. Weight of 10 rounds, 4 ozs. 5 drs.

AMMUNITION.—SMALL ARMS.

Dimensions, Weight, and Packing.

Description.			Charge.	Bore.	Bullet.				Proportions, 10 in a bundle.		Package.	
					Diameter.	Length.	Weight. Without Plug.	Weight. With Plug.	Caps.	Cartridges.	Average Weight.	Description.
			drams.	inches.	inches.	inches.	grains.	grains.	No.	No.	lb. oz.	
Smooth-Bore.	Musket.	Ordnance	3½	·753	·68	..	483	..	900	600	66 0	¼ Barrel.
		Common	4½	·753	·68	..	483	..	750	500	55 4	do.
	Carbine.	Carbine Bore	2¼	..	·60	..	350	..	1050	700	56 0	do.
		Victoria	2½	·753	·68	..	483	..	1050	700	69 0	do.
	Pistol.	Musket Bore	2½	·753	·68	..	483	..	1050	700	69 0	do.
		Carbine Bore	2	..	·60	..	350	..	1050	700	60 0	do.
		Pistol Bore or S. S.	2	·570	·51	..	205	..	..	2600	131 10	½ Case.
		·556 or 27 to a pound	1½	..	..	..	..	..	..	..	..	..
Rifle-Bore.	Musket.	1842 Pattern, S.S.	2¾	·758	·731	1·072	813	825	750	500	78 4	¼ Barrel.
									..	1300	176 12	½ Case.
									510	340	57 8	S. A. Box.
		1851 Pattern	2½	·702	·675	1·025	662	670	750	500	67 4	¼ Barrel.
									600	400	56 0	S. A. Box.
		Snider Breech-loading Enfield	2½	·577	·573	1·12	..	..	..	500	59 0	S. A. Box.
		1853 Pattern, Enfield	2½	·577	·55	1·095	524	530	1050	700	74 8	¼ Barrel.
									..	1600	174 6	½ Case.
									660	440	51 8	S. A. Box.

Rifle-bore. Musket.	1864 Pattern, Whitworth . .	grains. 75	·49 / ·45	·442	1·292	480	..	750	500	56 2	¼ Barrel.
	Westley Richards Br.-loading	70	·449 / ·451	·468 / ·458	1·16	530	..	900	600	67 0	do.
	Brunswick Belted ball. . .	drams. 2¼	..	·766 / ·64	..	..	..	900	600	65 10	do.
Carbine.	1861 Pattern, Artillery . .	2	·577	·55	1·095	524	530	1125 / 660	750 / 440	79 0 / 50 4	do. / S. A. Box.
	1861 Cavalry	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.
	Lancaster Oval Bore . . .	2¼	·577 / ·593	·55	1·095	524	530	1050	700	74 8	¼ Barrel.
	1858 Naval Rifle . . .	do.	·577	do.	do.	do.	do.	do.	do.	do.	do.
	Lancaster Double-barrelled .	2¼	·753	·726	1·034	717	..	750	500	73 0	do.
	Paget E. W. Y. C. . . .	1¾	·653	·685	1·003	700	..	1050	700	89 0	do.
	Sharp Breech-loading . . .	2¼	·551	·568	1·107	566	..	750	500	73 0	do.
	Terry Breech-loading . . .	2	·539	·568	·983	530	..	900	600	65 6	do.
	Westley Richards Br.-loading	2	·449 / ·451	·462 / ·448	1·015	400	..	1200	800	69 0	do.
Pistol.	Colt Revolver, 84 Gauge or Medium	grains. 13	·358	·38	·612	135	..	..	5292 / 2250	149 0 / 69 4	¼ Case. / ¼ Case.
	Deane Revolver 54 Gauge	15	·434	·457	·63	214	..	..	1920	88 4	do.
	Deane Revolver 38 Gauge	20	·470	·492	·66	245	..	..	1500	78 8	do.
	Rifled	drams. 1	·577	·568	·863	390	..	1350	900	79 0	¼ Barrel.
Blank.	For all Arms	3¼	..	..	..	..	..	1980	1800	45 8	¼ Barrel.
	Pistol	2	..	..	..	..	..	2750	2500	50 0	do.
	Sharp Breech-loading . . .	3	..	..	..	..	..	836	760	..	S. A. Box.
	Terry Breech-loading . . .	3	..	..	..	..	..	2750	2500	52 10	¼ Barrel.
	Westley Richards' Breech-loading Carbine / Musket	grains. 75	..	..	..	..	..	2750	2500	52 8	do.

Cartridges, Dimensions, &c.

Nature of Ord-nance.	Charge.	Purpose for which each Charge is intended. Land Service.	Sea Service.	Cartridge, how Marked.
	lb.	GUNS.		
10-In.	12	Service	Full	10 IN. 12 LB.
	8	Martin Shell, Carcass Saluting or Exercising. . . .	Martin Shell, Carcass, and Reduced	10 IN. 8 LB.
8-In.	10	Service, 65 & 60 cwt. Gun	Distant, 65 and 60 cwt. Gun . .	8 IN. 65 OR 60 D 10 LB.
	8	Service, 52 or 50 cwt. and Martin Shell	Full, and Martin Shell	8 IN. 8 LB.
	5	Saluting or Exercising.	Reduced, with Coal-dust wad. . .	8 IN. 5 LB.
150-Pr.	40	. . . .	Battering	150 PR. 40 LB.
	35	. . . .	Full.	150 PR. 35 LB.
	20	. . . .	Reduced and Saluting	150 PR. 20 LB.
	25	. . . .	Battering	100 PR. 25 LB.
100-Pr.	20	. . . .	Full.	100 PR. 20 LB.
	12	. . . .	Reduced and Saluting	100 PR. 12 LB.
68-Pr.	18	Service, 113 cwt. Gun .	. . . .	68 PR. 18 LB.
	16	Service, 95 cwt. Gun .	Distant, 95 cwt. Gun .	68 PR. 16 LB.
	14	Service, 87 cwt. Gun .	Distant, 87 cwt. Gun .	68 PR. 14 LB.
	12	. . . .	Full, 95 cwt. Gun. .	68 PR. 12 LB.
	10	Martin Shell . . .	Full, 87 cwt. Gun, and Martin Shell	68 PR. 10 LB.
	8	Saluting or Exercising.	Reduced, 95 cwt. Gun	68 PR. 8 LB.
	6	. . . .	Reduced, 87 cwt. Gun	68 PR. 6 LB.
56-Pr.	14	Service	. . . .	56 PR. 14 LB.
	8	Saluting or Exercising.	. . . .	56 PR. 8 LB.
42-Pr.	14	Service, 84 cwt. Gun .	. . . .	42 PR. 14 LB.
	12	Service, 75 cwt. Gun .	. . . .	42 PR. 12 LB.
	10½	Service, 67 cwt. Gun and Hot Shot, 84 cwt. Gun . .	. . . .	42 PR. 10½ LB.
	8	Saluting or Exercising	. . . .	42 PR. 8 LB.
32-Pr.	10	Service, 63, 58, and 56 cwt. Guns . .	Distant, 58 or 56 cwt. Guns	32 PR. 58 OR 56 D 10 LB.
	8	Service, 50 to 48 cwt. Guns	Full, 58 to 48 cwt. Guns	32 PR. 8 LB.
	7½	Hot Shot, 63 to 56 cwt. Guns . .	Hot Shot, 58 or 56 cwt. Guns . .	32 PR. 7½ LB.
	7	Service, 45 cwt. Gun .	Full, 45 cwt. Gun . .	32 PR. 7 LB.
	6	Service, 46, 42, 41, 40 and 39 cwt. Guns	Reduced, 58 or 56 cwt. Guns; Full, 42, 41, 40, 39 cwt. Guns	32 PR. 6 LB.
	5	Service, 32 cwt. Gun .	Reduced, 50, 48, and 45 cwt. Guns; Full, 32 cwt. Gun . .	32 PR. 5 LB.
	4	Saluting or Exercising 39 cwt. and upwards. Service, 25 cwt. Gun. .	Reduced, 42 to 39 cwt. Gun; Full, 25 cwt. Gun. . .	32 PR. 4 LB.
	3	Saluting or Exercising 32 cwt. Gun	Reduced, 32 cwt. Gun	32 PR. 3 LB.

Cartridges, Dimensions, &c.—continued.

Nature of Ord-nance.	Charge.	Purpose for which each Charge is intended. Land Service.	Sea Service.	Cartridge, how Marked.
	lb.			
		GUNS—*continued.*		
32-Pr.	2½	Saluting or Exercising 25 cwt. Gun	Reduced, 25 cwt. Gun	32 PR. 2½ LB.
	2	. . . .	Saluting	32 PR. 2 LB.
24-Pr.	8	Service, 50 & 48 cwt. Guns	. . . .	24 PR. 8 LB.
	6	Service, 41 cwt. Gun and Hot Shot, 50 and 48 cwt. Guns .	. . . .	24 PR. 6 LB.
	5	Saluting or Exercising 50 and 48 cwt. Guns . .	. . . .	24 PR. 5 LB.
	4	Service, 33 cwt. Gun, Saluting or Exercising 41 cwt. Guns	. . . .	24 PR. 4 LB.
	3	Saluting or Exercising 33 cwt. Guns	. . . .	24 PR. 3 LB.
	2½	Service, Saluting or Exercising 20 cwt. Guns	. . . .	24 PR. 2½ LB.
18-Pr.	6	Service, 42 to 38 cwt. Guns	. . . .	18 PR. 6 LB.
	4½	Hot Shot, 42 to 38 cwt. Guns	. . . .	18 PR. 4½ LB.
	4	Saluting or Exercising 42 to 38 cwt. Guns	. . . .	18 PR. 4 LB.
	3	Service, Saluting or Exercising 22 to 20 cwt. Guns . .	Full, 22 or 20 cwt. Guns	18 PR. 3 LB.
	2	Service, Saluting or Exercising 15 cwt. Guns	Reduced, 22 or 20 cwt. Guns; Full, 15 cwt. Gun .	18 PR. 2 LB.
12-Pr.	4	Service, Iron and Bronze	. . . .	12 PR. 4 LB.
	3	Saluting or Exercising Bronze, and 34, 33, 29½ cwt. Iron Guns . .	. . . .	12 PR. 3 LB.
	2½	Saluting or Exercising 21 cwt. Iron Guns	. . . .	12 PR. 2½ LB.
9-Pr.	3	Service Iron Guns . .	. . . .	9 PR. 3 LB.
	2½	Service Bronze Guns .	. . . .	9 PR. 2½ LB.
	2	Saluting or Exercising Iron Guns	. . . .	9 PR. 2 LB.
	1½	Saluting or Exercising Bronze Guns	. . . .	9 PR. 1½ LB.
6-Pr.	2	Service Iron Guns . .	. . . .	6 PR. 2 LB.
	1½	Service, Bronze Guns, Saluting or Exercising Iron Guns	. . . .	6 PR. 1½ LB.
	1	*Saluting or Exercising Bronze Guns*	. . . .	6 PR. 1 LB.

Cartridges, Dimensions, &c.—continued.

Nature of Ordnance.	Charge.	Purpose for which each Charge is intended.		Cartridge, how Marked.
		Land Service.	Sea Service.	
	lb.	GUNS—*continued.*		
6-Pr.	¼	. . . .	Practice	6 PR. 4 OZ.
	oz.			
3-Pr.	12	Service, Saluting or Exercising, Bronze 3 cwt. Guns . .	. . . .	3 PR. 12 OZ.
	10	Service, Saluting or Exercising, Bronze 2¼ cwt. Guns . .	. . . .	3 PR. 10 OZ.
1-Pr.	6	Service	. . . .	1 PR. 6 OZ.
	lb.	HOWITZERS.		
10-In.	7	Service	. . . .	10 IN. HOW. 7 LB.
	4	Saluting or Exercising	. . . .	10 IN. HOW. 4 LB.
8-In.	4	Service	. . . .	8 IN. HOW. 4 LB.
	3	Saluting or Exercising.	. . . .	8 IN. HOW. 3 LB.
32-Pr.	3	Service	. . . .	32 PR. HOW. 3 LB.
	2	Saluting or Exercising.	. . . .	32 PR. HOW. 2 LB.
24-Pr.	2½	Service	. . . .	24 PR. HOW. 2½ LB.
	1½	Saluting or Exercising.	. . . .	24 PR. HOW. 1½ LB.
5½-In.	2	Service, Saluting or Exercising 15 cwt. Iron	. . . .	5½ IN. HOW. 2 LB.
12-Pr.	2	. . . .	Service, 10 cwt. . .	12 PR. HOW. 2 LB.
	1¼	Service, 6½ cwt. . .	. . . .	12 PR. HOW. 1¼ LB.
	1	Saluting or Exercising 6½ cwt. .	. . . .	12 PR. HOW. 1 LB.
	oz.			
4⅖-In.	8	Service, 2¼ cwt. Coehorn	. . . .	4⅖ IN. HOW. 8 OZ.
	4	Saluting or Exercising 2¼ cwt., Coehorn .	. . . .	4⅖ IN. HOW. 4 OZ.
	lb.	MORTARS.		
13-In.	20	. . . .	Service	13 IN. MOR. 20 LB.
	16	. . . .	Carcass	13 IN. MOR. 16 LB.
	9	Service	. . . .	13 IN. MOR. 9 LB.
10-In.	9¼	. . . .	Service	10 IN. MOR. 9¼ LB.
	4	Service	. . . .	10 IN. MOR. 4 LB.
8-In.	2	Service	. . . .	8 IN. MOR. 2 LB.
	oz.			
5½-In.	7	Service, Royal . . .	. . . .	5½ IN. MOR. 7 OZ.
4⅖-In.	5	Service, Coehorn . .	. . . .	4⅖ IN. MOR. 5 OZ.
		CARRONADES.		
	lb.			
68-Pr.	5	. . . .	. . . .	68 PR. CARDE. 5 LB.
42-Pr.	3½	. . . .	. . . .	42 PR. CARDE. 3½ LB.
32-Pr.	2 11/16	. . . .	. . . .	32 PR. CARDE. 2 11/16 LB.
24-Pr.	2	. . . .	. . . .	24 PR. CARDE. 2 LB.
18-Pr.	1½	. . . .	. . . .	18 PR. CARDE. 1½ LB.
12-Pr.	1	. . . .	. . . .	12 PR. CARDE. 1 LB.
	oz.			
6-Pr.	10	. . . .	. . . .	6 PR. CARDE. 10 OZ.

BOXES FOR PACKING PROJECTILES.

Smooth Bore Ordnance.

No. of Box.	Ordnance, Nature.	Projectile, Description.	No. in each Box.	Weight. Boxes.	Projectile.			Total.			
				lb.	lb.	oz.	dr.	cwt.	qr.	lb.	oz.
1	13 Inch Mortar	Shell	1	23·12	206	0	11	2	0	5	5¾
2	10 Inch Gun .	„ Common .			85	8	0	0	3	18	4
„	„ „ .	„ Martin . .	1	16·8	68	9	0	0	3	1	5
„	„ „ .	„ Naval . .			86	0	13	0	3	18	13
3	„ „ .	Grape			82	12	12	1	2	21	0
„	„ „ .	Case	2	23·4	79	3	4	1	2	13	12¾
„	„ Howitzer	„			89	7	8	1	3	6	5¼
4	8 In. or 68 Pr. Gn.	Shell, Diaphragm	1	10·4	60	10	0	0	2	15	0¼
„	„ „ .	„ Naval . .			50	4	6	0	2	4	12¾
5	8 Inch Gun .	„ Common .			49	12	13	1	0	4	3¼
„	„ „ . .	„ Martin .			28	3	4	0	2	17	0⅛
„	„ „ . .	Case	2	16·6	47	4	0	0	3	27	1⅝
„	„ Howitzer	„			34	0	8	0	3	0	10⅝
„	68 Pr. Carronade	„			48	7	3	1	0	0	15
„	„ „ .	Grape			48	12	0	1	0	1	5
6	68 Pr. Gun . .	„	2	20·12	67	0	8	1	1	14	2
7	56 Pr. Gun. .	„	2	16·15	69	8	12	1	1	15	4
„	„ „ . .	Case			52	5	0	1	0	8	12¼
8	42 Pr. Gun . .	„			45	5	0	1	3	16	0¾
„	„ „ . .	Grape	4	30·8	48	10	12	2	0	1	7¾
„	„ Carronade	„			38	5	9	1	2	15	6
9	„ Gun . .	Shot			41	6	12	1	2	19	13
„	„ „ . .	Shell	4	21·4	31	5	10	1	1	7	14
„	„ Carronade	Case			35	2	0	1	1	21	12
10	„ Gun . .	Shell	1	7·7	31	5	10	0	1	10	0 13/16
11	32 Pr. Gun . .	Grape			37	8	8	1	2	3	5
„	„ „ . .	Case	4	21·1	34	11	8	1	1	19	15
„	„ Carronade	Grape			29	4	0	1	0	26	1
12	„ Gun . .	Shot			31	6	0	1	1	4	8
„	„ „ .	Shell, Common			23	9	4	1	0	1	5
„	„ „ .	Shell, Diaphragm	4	19·0	28	6	10	1	0	20	10½
„	„ Carronade	Case			21	14	8	0	3	22	10
„	„ Howitzer	„			22	5	8	0	3	24	6
13	„ Gun . .	Naval Shell . .	1	6·10	23	8	12	0	1	1	9¾
14	24 Pr. Gun . .	Grape	6	26·8	26	2	8	1	2	15	11¾
„	„ „ . .	Case			24	2	4	1	2	3	10¼
15	„ „ .	Shell, Diaphragm	6	20·12	21	0	0	1	1	7	0 11/16
„	„ „ .	Shell, Common .			17	9	15	1	0	14	2¼
„	„ „ . .	Shot			23	8	12	1	1	21	6
„	„ Carronade	Grape			18	11	12	1	0	21	2½
„	„ Carronade	Case			17	9	12	1	0	14	6
„	„ Howitzer.	„ L.S. . . .	6	20·12	13	8	8	0	3	17	4¾
„	„ „ . .	„ S.S. . . .			15	14	12	1	0	3	10¼
„	5½ Inch „ .	Shell			20	10	0	1	1	4	8
„	5½ Inch „ .	Case			13	13	4	0	3	19	1¼
16	*18 Pr. Gun .*	*Grape . . . .*	8	18·10	18	13	12	1	2	0	16
		Case			19	3	0	1	2	3	9

BOXES FOR PACKING PROJECTILES—*continued.*

Smooth Bore Ordnance.

No. of Box.	Ordnance, Nature.	Projectile, Description.	No. in each Box.	Weight. Boxes.	Projectile.			Total.			
				lb.	lb.	oz.	dr.	cwt.	qr.	lb.	oz.
17	18 Pr. Gun . .	Shell { Diaphragm			15	15	8	1	1	8	13
"	" " . .	Shell { Common .			12	10	4	1	0	14	7¾
"	" " . .	Shot	8	20·12	18	3	8	1	1	25	14
"	18 Pr. Carronade	Grape			14	6	0	1	0	23	12
"	" " . .	Case			13	9	0	1	0	17	4
18	12 Pr. Gun . .	"	12	24·7	16	11	12	2	0	1	8¼
19	" " . .	Grape			12	11	8	1	2	5	11
"	" Carronade	"			10	4	0	1	1	4	10
"	" " . .	Case	12	21·10	8	15	0	1	0	16	14
"	" Howitzer	" L.S. . . .			7	14	12	1	0	4	2
"	" " . .	" S.S. . . .			8	15	8	1	0	16	11
"	4⅖ Inch " . .	"			8	1	4	1	0	6	0
20	12 Pr. Gun .	Shell { Diaphragm			10	4	4	1	1	0	5
"	" " .	Shell { Common .	12	17·13	8	15	0	1	0	12	6
"	" " . .	Shot			12	8	0	1	1	27	2
"	4⅖ In. Howitzer	Shell			10	1	0	1	0	26	9
21	9 Pr. Gun . .	Case	12	22·12	13	6	0	1	2	9	10
22	" " . .	Grape	12	17·6	10	7	0	1	1	2	13¼
23	" " . .	Shell, Diaphragm	12	18·4	7	13	10	1	0	0	10
"	" " . .	Shot			9	5	8	1	0	18	8¼
24	6 Pr. Gun . .	Shell, Diaphragm	24	23·8	5	1	2	1	1	5	7¾
"	" " . .	Shot			6	3	0	1	2	4	4¾
25	" " . .	Case	12	14·14	8	11	12	1	0	6	15
26	" " . .	Grape	12	13·10	6	9	8	0	3	4	3
27	3 Pr. Gun . .	Case	30	18·0	4	5	0	1	0	25	6
"	" " . .	Shot	60		3	1	8	1	3	7	7
28	" " . .	Grape	60	21·15	2	9	0	1	2	3	12
	13 Inch Mortar.	1 lb. Shot . . .	100	12·8¼		..		1	0	0	8¼

CARTRIDGES, DIMENSIONS, ETC.

Rifled Ordnance.

Nature of Ordnance. — Armstrong Guns.	Charge.	Purpose for which each Charge is Intended.		Cartridge, how Marked.
		Land Service.	Sea Service.	
	lb.			
7-inch B.L.	11	Service, heavy 7-inch Gun .	Service	7-in. B.L. 11 lb.
	10	Service, light 7-inch Gun . .	.. ..	7-in. B.L. 10 lb.
64 Pr. B. L.	8	Service, Shot and Shell . .	Full	64-pr. B.L. 8 lb.
M. L. . .	8	.. ..	Full	64-pr. M.L. 8 lb.
	6	.. ..	Reduced and Saluting . . .	64-pr. M.L. 6 lb.
40 Pr. . .	5	.. ..	Service, Shot and Shell . .	40-pr. B.L. 5 lb.
		Service, Shot and Shell . .	.. ..	40-pr. B.L. 5 lb.
	3*	Saluting and Exercising . .	.. ..	40-pr. B.L. 3 lb.
20 Pr. . .	2½	Service, Shot and Shell . .	Service, Shot and Shell . .	20-pr. B.L. 2 lb. 8oz.
	1½*	Saluting and Exercising . .	.. ..	20-pr. B.L. 1lb. 8oz.
12 Pr. . .	1½	Service, Shot and Shell . .	Service, Shot and Shell. . .	12-pr. B.L. 1lb. 8oz.
	1*	Saluting and Exercising . .	Saluting and Exercising . .	12 or 9-pr. B.L. 1 lb.
9 Pr. . .	1⅛	Service, Shot and Shell . .	Service, Shot and Shell . .	9-pr. B.L. 1 lb. 2oz.
	1*	Saluting and Exercising . .	Saluting and Exercising . .	12 or 9-pr. B.L. 1 lb.
	oz.			
6 Pr. . .	12	Service, Shot and Shell . .	Service, Shot and Shell . .	6-pr. B.L. 12oz.

* Blank.

FILLED CANNON CARTRIDGES. *Rifled Ordnance.*

Nature.	Charge. — R.L.G. Powder.		Number Packed, and Weight of Package.																	
			Barrel Whole.		Ammunition Box.		Case, Powder, Copper-lined.						Case, Powder, Brass.							
							Whole.		Half.		Quarter.		Pentagon.		Sectional.		Rectangular.			
																	Plain.		Corrugated.	
			Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Number.	Weight.	Num.	Wght.	Num.	Wght.
	lb.	oz.		lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.		lb.
Breech-Loading. 7-Inch	11	0	6	102	3	56	8	140	3	63	..	..	7	141	..	..	9	174	9	155
	10	0	6	97	3	54	8	133	3	61	..	..	7	135	..	..	9	166	9	147
64-Pr.	8	0	6	96	2	42	7	121	2	50	..	..	6	124	..	..	7	143	7	124
40-Pr. S.S.	5	0	11	94	6	54	15	130	5	56	2	30	14	137	5	70	17	162	20	160
40-Pr. L.S.	5	0	10	96	4	47	12	123	5	61	..	..	12	136	4	67	13	151	16	151
20-Pr.	2	8	19	95	10	54	26	133	12	68	4	31	22	133	11	78	30	168	30	149
12-Pr.	1	8	42	112	21	60	50	142	25	76	9	35	50	155	23	86	58	180	64	170
9-Pr.	1	2	60	122	30	67	70	154	32	77	12	36	63	156	28	85	72	179	80	170
6-Pr.	0	12	86	120	49	71	100	150	48	78	18	36	93	155	46	89	108	180	129	182
Muzzle-Loading. 10-Inch	50	0	..	..	1	72	..	..	..	..	..	..	..	..	..	..	1	121	2	152
	45	0	1	79	1	66	..	..	..	..	..	..	..	..	..	..	2	161	2	142
	35	0	2	104	1	57	..	..	..	..	..	..	..	..	..	..	3	176	3	157
9-Inch	43	0	..	..	1	61	..	..	..	..	..	..	..	..	..	..	1	114	3	181
	30	0	2	94	1	52	3	139	..	..	..	..	..	..	..	..	3	161	4	172
	15	0	5	109	2	52	7	154	..	..	..	..	7	168	..	..	7	177	8	173
8-Inch	30	0	2	94	1	52	2	109	..	..	..	..	2	122	..	..	3	161	3	142
	20	0	4	114	2	62	5	149	..	..	..	..	5	162	..	..	5	171	5	152
	12	0	7	118	3	58	9	158	4	77	..	..	9	171	..	..	9	179	10	172
7-Inch	22	0	3	100	2	66	5	159	..	..	..	..	4	150	..	..	5	182	5	163
	14	0	6	118	3	64	7	148	3	72	..	..	7	160	..	..	7	170	8	164
	10	0	9	126	4	63	11	161	4	71	..	..	11	174	..	..	12	193	14	193
64-Pr.	8	0	12	130	5	63	14	162	6	78	..	..	14	175	..	..	16	200	18	197
	6	0	16	130	8	71	19	164	8	78	..	..	19	177	..	..	21	199	24	197
7-Pr.	0	8	200	136	110	78	230	167	110	86	40	39	230	182	105	98	260	201	280	197

SMOOTH BORE ORDNANCE.

SHELLS.

Shells are hollow iron Shot, and are of various descriptions, viz. :—

1st.—The *Common shell*, with one fuze hole, used in the attack, and defence of fortresses, &c., against shipping, and troops.

2nd.—The *Carcass*, which has three fire-holes, is filled with burning composition, and is used to set fire to towns, &c.

3rd. The *Shrapnel shell*, which is very destructive when used against bodies of Cavalry, or Infantry, as it produces the same effect as common Case or Canister shot from guns, or howitzers, but at a much greater range.

Nature and Description.	Mean. lb.	Mean. oz.
Shells, Common, empty, riveted to elm bottoms, and plugged—		
10 Inch	79	4½
8 Inch	47	4¾
56 Pr.	40	2
42 Pr.	29	11
32 Pr.	22	5¼
24 Pr.	16	11¾
18 Pr.	12	10¼
12 Pr.	8	9½
Shells, Diaphragm, Shrapnel, empty, riveted to elm bottoms, and plugged—		
150 Pr.	140	8
100 Pr.	86	7
8 Inch	60	5
56 Pr.	51	7
42 Pr.	37	14
32 Pr.	28	3½
24 Pr.	21	0
18 Pr.	15	15½
12 Pr.	10	2¾
9 Pr.	7	12½
6 Pr.	5	0½
Shell, Hand-grenade, empty—		
6 Pr. (Sea service) .	3	9¼
3 Pr. (Land service)	1	11¼
Shell, Martin, empty, riveted and plugged—		
10 Inch	*68*	*9*
8 Inch	*28*	*3¼*
Shell, Mortar, empty, loose—		
13 Inch	195	3
13 Inch	195	6
10 Inch	87	2
8 Inch	46	1
5½ Inch	16	3
4⅖ Inch	8	5
Shell, Naval, empty, riveted and plugged—		
Top, 150 Pr. . . .	107	10
Bottom, 10 Inch . .	79	13
Top, 100 Pr. . . .	67	6
Bottom, 8 Inch . .	47	13¼
Bottom, 32 Pr. . .	22	6¼
Shot, Solid, loose—		
150 Pr.	150	3½
10 Inch	125	11
100 Pr.	93	8¾
68 Pr.	66	3¼
56 Pr.	55	8¾
42 Pr.	41	6¾
32 Pr.	31	6
24 Pr.	23	8¾
18 Pr.	17	11¾
12 Pr.	12	4¼
9 Pr.	9	2
6 Pr.	6	0¼
3 Pr.	2	15¾
Shot, Solid, riveted—		
18 Pr.	18	3½
12 Pr.	12	8
9 Pr.	9	5¼
6 Pr.	6	3
3 Pr.	3	1¼

Nature and Description.	Mean. lb.	oz.
Carcasses, empty—		
13 Inch	220	15
10 Inch	98	10¼
8 Inch	49	15¼
32 Pr.	24	3¾
24 Pr.	18	0¼
18 Pr.	13	12
12 Pr.	8	15¾
Carcasses, filled, loose—		
13 Inch	234	0
10 Inch	103	1
8 Inch	52	12
Carcasses, filled, riveted—		
32 Pr.	28	8
24 Pr.	16	11
18 Pr.	14	2
12 Pr.	9	1
Shot, Case, Gun—		
150 Pr.	144	0
10 Inch	79	3¼
100 Pr.	99	12
8 Inch	47	4
56 Pr.	52	5
42 Pr.	45	5
32 Pr.	34	11½
24 Pr.	24	2¼
18 Pr.	19	3

Nature and Description.	Mean. lb.	oz.
Shot, Case, Gun—		
12 Pr.	16	11¾
9 Pr.	13	6
6 Pr.	8	11¾
3 Pr.	4	5
Shot, Case, Howitzer—		
10 Inch	89	7½
8 Inch	34	0¼
32 Pr.	22	5½
24 Pr. (Sea service)	15	14¾
24 Pr. (Land service)	13	8½
5½ Inch	13	13¼
12 Pr. (Sea service)	8	15½
12 Pr. (Land service)	7	14¾
4⅖ Inch	8	1¼
Shot, Grape, Caffin—		
10 Inch	82	12¾
10 Inch	82	12¼
68 Pr.	67	0½
56 Pr.	69	8¾
56 Pr.	69	8½
42 Pr.	48	10¾
32 Pr.	37	8½
24 Pr.	26	2½
18 Pr.	18	13¾
12 Pr.	12	11½
9 Pr.	10	7
6 Pr.	6	9½

SHELL, DIAPHRAGM. BOXER.

The several sizes are 6, 9, 12, 18, 24, 32, 42, 56, 8-inch; or 68-Pr., 100-Pr., and 150-Pr. Each shell contains the following number of bullets, hardened with antimony:—

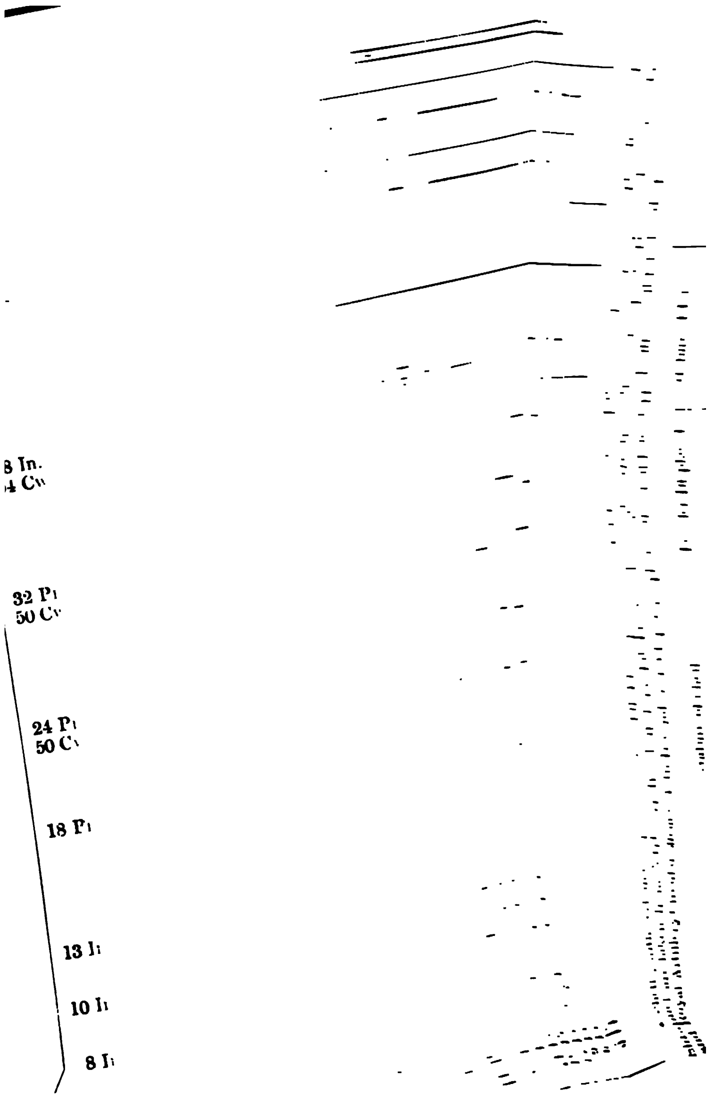
150-Pr.	802	18-Pr.	75
100-Pr.	484	12-Pr.	72
68-Pr.	339	9-Pr.	52
32-Pr.	152	6-Pr.	29
24-Pr.	110		

All diaphragm shell are fitted with a metal socket, the top of which is flush with the surface of the shell. Diaphragm shell, whether filled (bursting charge in them) or empty, are issued riveted to wood bottoms, and packed in boxes. If issued filled, they are for Naval service.

SHELL, MARTIN.

The Martin shell is an incendiary shell of iron, lined with clay; *and is filled with* molten iron before being fired.

Nature.	Diameter of Shell.		Bullets, Number of.					Weight, filled, with Metal Plug, Wood Bottom, and Burster.	
	Greatest.	Least.	Musket.	Carbine.	Pistol.	Buck.	Total.		
	Inches.	Inches.						lb.	oz.
150-Pr.	10·42	10·38	254 2-oz. Sand Shot . 30 ,, ,, .				284	122	0
100-Pr.	8·92	8·8	484	..	..	..	484	86	0
8-Inch or 68-Pr.	7·95	7·9	338	1	1	1	341	60	13
56-Pr.	7·51	7·45	284	1	1	1	287	52	5
42-Pr.	6·795	6·735	210	1	1	1	213	38	5
32-Pr.	6·207	6·147	151	1	1	1	154	28	15
24-Pr.	5·62	5·57	110	1	1	1	113	21	5
18-Pr.	5·124	5·074	77	1	1	1	80	15	5
12-Pr.	4·476	4·432	..	72	1	1	74	10	12
9-Pr.	4·1	4·06	..	52	1	1	54	7	14
6-Pr.	3·568	3·532	..	29	1	1	31	5	13


8 In.
32 P
50 C
24 P
50 C
18 P
13 I
10 I
8 I

Nature of Shell.	Description of Shell.					Calico Bag.	
	Common.		Segment.			Common.	Segment.
	Approximate Charge.	Nature of Powder.	Approximate Charge.		Nature of Powder.	Number.	Number.
	lb. oz. dr.		lb. oz. dr.				
7-Inch B.L., old pattern, 98 lb. weight	7 10 0	"Shell, L.G."	3 2 0		"Shell, L.G."	7	6
" present do., 83¾ lb. do.	6 8 0	do.	..		do.	7	..
64-Pr. B.L.	4 8 0	do.	2 12 0		do.	7	6
64-Pr. M.L.	4 13 0	do.	1 15 0		do.	7	5
40-Pr.	2 4 0	do.	0 13 0		do.	5	4
			Fuze.				
			Iron Concussion.	C Percussion, Dyer Pattern.			
			Grains.	Grains.			
20-Pr.	1 2 0	do.	534	700	"F.G."	5	..
12-Pr.	0 9 8	do.	260	550	do.	4	..
9-Pr.	0 6 8	do.	..	300	do.	..	..
7-Pr., M. L.	0 7 0	do.	..	..	..	..	..
6-Pr.	..	..	132	200	do.	..	..

* By Order, 22nd September, 1864, W.O.C., No. 3 (new series), paragraph 954; also, W.O.C. 884; and Royal Artillery Circular Memorandum, 13th December, 1864, Paragraph 3; all shells, except diaphragm, were directed to be completely filled by capacity, instead of, as formerly, by weight, "the powder being well shaken down by tapping the shell with a mallet during the process." The bursting charge is, therefore, only approximate, varying with the density of the powder, and the slightly varying thickness of the metal, and consequent capacity of the shell. Bursters, whether calico or iron, accordingly disappear, except for field and siege artillery, and for all diaphragm shells and the lower natures of segment shells for all services, with which they are still employed. As regards the bursting charges for the four lower natures of segment shells, the iron bursters in which they are placed have been filled by capacity since 1862. ("The bursters to be filled, without regard to quantity, provided it is not less than appears in the specification, and the powder to be well shaken down.")

Charges, Bursting, *Approximate.**

Nature of Shell.	Common.			Naval.			Mortar.			Shrapnel Improved.			Shrapnel Diaphragm.			Hand Grenades.		Number of Calico and Paper Bags.	
										Charge.	Bullets.		Charge.	Bullets.		Sea Service.	Land Service.	Common Mortar and Hand Grenades.	Diaphragm.
	lb.	oz.	dr.	lb.	oz.	dr.	lb.	oz.	dr.	dr.	Size.	No.	dr.	Size.	No.	oz.	oz.	No.	No.
13-Inch . . .		..			..		10	15	0	..	..	..	..	..	..	..	..	7	..
10-Inch . . .	6	12	0	6	5	0	5	4	0	..	..	..	..	..	..	..	..	7	..
8-Inch, or 68-Pr.	2	9	0	2	9	0	2	9	0	67	Musket	370	80	Musket	341	..	..	6	4
150-Pr. . . .		..		6	14	0		..		..	..	..	128	30, & 254 2-oz. Sand Shot.		..	..	6	..
100-Pr. . . .		..		3	13	0		..		..	..	..	96	do.	484	..	..	6	4
56-Pr. . . .	2	7	0		..			..		66	do.	..	70	do.	287	..	..	5	3
42-Pr. . . .	1	12	0		..			..		44	do.	..	60	do.	213	..	..	5	3
32-Pr. . . .	1	5	0	1	5	0		..		40	do.	170	50	do.	154	..	..	5	3
24-Pr., or 5½-Inch	1	0	0		..		1	0	0	25¼	do.	119	40	do.	113	..	..	4	3
18-Pr. . . .	0	12	0		..			..		24	do.	90	30	do.	80	..	..	4	2
12-Pr., or 4⅗-Inch	0	7	0		..		0	7	0	16½	Carbine	80	24	Carbine	74	..	..	4	2
9-Pr. . . .		..			..			..		14	do.	34	18	do.	54	..	..	..	1
6-Pr. . . .		..			..			..		9¼	do.	25	10	do.	31	5	..	3	1
3-Pr. . . .		..			..			..		..	..	..	..	..	..	..	3	2	..

* Shells, with certain exceptions, are now filled by capacity instead of by weight, and the charges here given, except in the case of Shrapnel, are taken from W.O.C. 927, the shells being filled in accordance with W.O.C. No. 3 (New Series), paragraph 954; also W.O.C. 884; and Royal Artillery Circular *Memo.*, 13th December, 1864, paragraph 3; "the shell being tapped with a mallet during the process."

Nature of Shell.	Powder Displaced.	Nature of Fuze.
Mortar { 13 and 10-Inch	Half-an-ounce.	Wood.—Mortar.
Mortar { 8-Inch.	One Ounce.	Do. do.

Nature of Shell.	Description of Shell. Common. Approximate Charge.	Common. Nature of Powder.	Segment. Approximate Charge.		Segment. Nature of Powder.	[illegible] Calico Bag. Common. Number.	Calico Bag. Segment. Number.
	lb. oz. dr.		lb. oz. dr.				
7-Inch B.L., old pattern, 98 lb. weight	7 10 0	"Shell, L.G."	3 2 0		"Shell, L G."	7	6
" present do., 53¾ lb. do.	6 8 0	do.	..		do.	7	..
64-Pr. B. L.	4 8 0	do.	2 12 0		do.	7	6
64-Pr. M.L.	4 13 0	do.	1 15 0		do.	7	5
40-Pr.	2 4 0	do.	0 13 0		do.	5	4
			Fuze. Iron Concussion.	Fuze. C Percussion, Dyer Pattern.			
			Grains.	Grains.			
20-Pr.	1 2 0	do.	534	700	"F.G."	5	..
12-Pr.	0 9 8	do.	260	550	do.	4	..
9-Pr.	0 6 8	do.	..	300	do.	..	..
7-Pr., M. L.	0 7 0	do.	..	..	..	..	..
6-Pr.	..	..	132	200	do.	..	..

* By Order, 22nd September, 1864, W.O.C., No. 3 (new series), paragraph 954; also, W.O.C. 884; and Royal Artillery Circular Memorandum, 13th December, 1864, Paragraph 3; all shells, except diaphragm, were directed to be completely filled by capacity, instead of, as formerly, by weight, "the powder being well shaken down by tapping the shell with a mallet during the process." The bursting charge is, therefore, only approximate, varying with the density of the powder, and the slightly varying thickness of the metal, and consequent capacity of the shell. Bursters, whether calico or iron, accordingly disappear, except for field and siege artillery, and for all diaphragm shells and the lower natures of segment shells for all services, with which they are still employed. As regards the bursting charges for the four lower natures of segment shells, the iron bursters in which they are placed have been filled by capacity since 1862. ("The bursters to be filled, without regard to quantity, provided it is not less than appears in the specification, and the powder to be well shaken down.")

SHOT, CASE, OR CANISTER.

The common Case or Canister shot consists of a number of balls packed in tin or iron canisters of a cylindrical form: the balls being of different weights according to the size of the gun. For field service the balls are counted into the case, and laid in tiers, but for other purposes they are loosely thrown in till the case is filled.

CASE SHOT FOR SMOOTH BORE ORDNANCE.

FOR LAND AND SEA SERVICES, AS SPECIFIED.

For Iron Guns, and Howitzers, Garrison, and Sea Service.—For 56, 42, 24, and 18-pounder Guns, and 10, and 8-inch Howitzers, the case consists of a tin cylinder with a tin top, and plate-iron bottom with a rope handle, filled with iron balls of different sizes.

For Carronades.—Cases for Carronades are prepared as above, but have fewer balls and weigh lighter.

Bronze Ordnance, Field Service.—For Brass Ordnance, viz., 12, 9, 6, and 3-pounder Guns, 32, 24, and 12-pounder, and $5\frac{1}{2}$, and $4\frac{2}{5}$-inch Howitzers, the cases are made of tin, fixed to wood bottoms, shaped cylindrical for 9, 6, and 3-pounder Guns; conical for Howitzers, and Guns of same calibre (except for the $5\frac{1}{2}$ and $4\frac{2}{5}$-inch Howitzers, which are cup-shaped). Iron cylinder for 10″, 8″, 68-pounder, and 32-pounder.

Sea Service.—24, and 12-pounder Howitzer cases have fewer but heavier balls than those for similar natures of Howitzers for Land Service, and weigh heavier.

Colour Painted.—Cases for *all* Guns are painted *red*, and for *all* Howitzers, *black*.

GRAPE SHOT.

For Garrison, and Sea Service Guns.—Grape Shot for Land Service are of Caffin's pattern; they consist of from 15 to 9 iron balls, of different sizes, arranged in 3 tiers, between horizontal iron plates, secured by an iron spindle and nut; they are painted *black*.

For the 10-inch Gun, and 68 and 32-pounder, 24 three-pound iron balls are packed in a sheet-iron cylinder, having plate-iron top and bottom, and an iron handle fitted on the top.

Carronades.—Carronade Grape is prepared as Case-shot, the balls are much heavier, and vary in number from 9 to 15, and the cylinder *is longer.*

Nature of Ordnance.			Shot. Weight of Each.	Shot. Total Number.	Total Weight. lb.	Total Weight. oz.
			oz.		lb.	oz.
Iron.						
Guns	150 Pr.		..	..	..	
			..	..	..	
	100 Pr.	O. P.	..	..	100	0
		N. P.	16	91		
	10 Inch	O.P.	16	34 } 84	80	5
			$13\frac{1}{8}$	50 }		
		N.P.	do.	do.	82	0
	8 Inch, or 68 Pr.	O. P.	8	90	48	3
		N. P.	do.	do.	50	8
	56 Pr.		16	50	52	$9\frac{3}{4}$
	42 Pr.		8	84	44	$6\frac{1}{2}$
	32 Pr.	O. P.	8	66	34	13
		N. P.	do.	do.	36	12
	24 Pr.		8	46	24	$12\frac{1}{2}$
	18 Pr.		6	46	19	$0\frac{1}{2}$
Howitzers	10 Inch		8	170	89	$0\frac{3}{4}$
	8 Inch		2	258	34	$12\frac{1}{2}$
Carronades	68 Pr.		8	90	48	$1\frac{1}{4}$
	42 Pr.		8	66	35	$6\frac{1}{4}$
	32 Pr.		8	40	22	$1\frac{1}{2}$
	24 Pr.		8	32	17	$11\frac{1}{4}$
	18 Pr.		6	31	13	$3\frac{3}{4}$
	12 Pr.		4	32	9	2
Bronze.						
Guns	12 Pr.		$6\frac{1}{2}$	41	16	$15\frac{1}{4}$
	9 Pr.		5	41	13	9
	6 Pr.		$3\frac{1}{4}$	41	8	$5\frac{3}{4}$
	3 Pr.		$1\frac{1}{2}$	41	4	7
Howitzers	L. S.	32 Pr.	$3\frac{1}{4}$	105	21	7
		24 Pr.	2	100	13	13
		12 Pr.	2	56	7	$13\frac{1}{2}$
		$5\frac{1}{2}$ Inch	2	100	13	$15\frac{3}{4}$
		$4\frac{2}{5}$ Inch	2	56	8	$0\frac{3}{4}$
	S. S.	24 Pr.	8	30	16	9
		12 Pr.	8	15 } 18	9	$3\frac{3}{4}$
			4	3 }		

Shot, Grape.

Nature of Ordnance.		Shot. Weight of each.	Shot. Number in a Tier.	Shot. Number of Tiers.	Shot. Total Number.	Plates. Number of Wrought Iron.	Plates. Number of Cast Iron.	Case. Depth.	Case. Diameter.	Total Weight.
	Iron.	lb.						inches.	inches.	lb. oz.
Guns	10 Inch*	3	8	3	24	2	..	8·1	9·82	81 7
	8 Inch, or 68 Pr.	3	5	3	15	1	3	..	..	65 9
	56 Pr.	4	4	3	12	1	3	..	..	69 7
	42 Pr.	4	3	3	9	1	3	..	..	48 11
	32 Pr.	3	3	3	9	1	3	..	..	36 12
	24 Pr.	2	3	3	9	1	3	..	..	25 3
	18 Pr.	$1\frac{1}{4}$	3	3	9	1	3	..	..	18 13
	12 Pr.	1	3	3	9	1	3	..	..	12 15
		oz.								
	9 Pr.	$13\frac{1}{8}$	3	3	9	1	3	..	..	10 12
	6 Pr.	8	3	3	9	1	3	..	..	6 11
		lb.								
Carronades	68 Pr.*	3	5	3	15	1	..	7·87	7·82	46 $8\frac{1}{2}$
	42 Pr.*	4	3	3	9	1	..	8·5	6·35	38 $8\frac{1}{2}$
	32 Pr.*	3	3	3	9	1	..	7·6	6·147	28 $3\frac{1}{4}$
	24 Pr.*	2	3	3	9	1	..	6·4	5·57	18 $9\frac{3}{4}$
	18 Pr.*	$1\frac{1}{4}$	3	3	9	1	..	6·0	5·074	14 $6\frac{1}{4}$
	12 Pr.*	1	3	3	9	1	..	5·4	4·432	10 0

*Shot, Solid, Cast-Iron, and Steel.**

Dimensions, &c.	Nature.											
	150 Pr.	100 Pr.	68 Pr.	56 Pr.	42 Pr.	32 Pr.	24 Pr.	18 Pr.	12 Pr.	9 Pr.	6 Pr.	3 Pr.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Diameter, Mean . .	10·4	8·9	7·925	7·48	6·765	6·177	5:6115	5·099	4·5225	4·1	3·568	2·823
	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Average Weight . .	150 3¼	93 8¾	66 3¼	55 8¾	41 6¾	31 6	23 8¼	17 11¾	12 4¼	9 4¼	6 ¼	2 15¾

* Steel Shot are made only for the 150, 100, and 68 Pr. Guns. Their dimensions are the same as those of solid cast iron of these calibres.

COMBUSTIBLE COMPOSITION FOR LABORATORY STORES.

CARCASSES.

Weight, and Dimension of Carcasses.

Nature of Carcass. Land Service.	Mean Exterior Diameter.	Weight, empty.	Weight, filled, about.
	inches.	lb. oz.	lb. oz.
13 Inch	12·84	220 0	234 0
10 Inch	9·85	96 0	105 0
8 Inch, 68 Pr. . .	7·86	48 0	53 0
56 Pr.	7·48	..	..
42 Inch	6·77	..	30 8
32 Inch	6·177	24·4	26 12
24 Inch	5·595	18·0	19 4
18 Inch	5·099	..	14 12
12 Inch	4·454	9·0	9 8

Carcass Composition.

	lb.	oz.
Saltpetre, ground.	6	4
Sulphur, ground	2	8
Rosin, pounded	1	14
Antimony, sulphide of	0	10
Tallow, Russian	0	10
Turpentine, Venice	0	10

Burn from 3 to 12 minutes.

BALLS, GROUND LIGHT.

	lb.	oz.	dr.
Saltpetre, ground	6	4	0
Sulphur, ground	2	8	0
Rosin, pounded	1	14	0
Oil, linseed, boiled	0	7	8

Burn from 9 to 16 minutes.

BALLS, LIGHT, PARACHUTE, BOXER.

	lb.	oz.
Saltpetre, ground	7	0
Sulphur, sublimed	1	12
Orpiment, red.	0	11

Fired from mortars, with low charges.

Weights, and exterior Dimensions of these Balls.

	Weight about	Mean.	Diameter, Greatest.	Least.
10 Inch	. 31¾ lbs.	9·85	9·88	9·82
8 „	. 15 lbs.	7·83	7·9	7·76
5½ „	. 6¾ lbs.	5·545	5·57	5·52

Time of burning—

10 inch,	about	3	minutes,	0	seconds.
8 „	„	1	„	40	„
5½ „	„	1	„	0	„

BALLS, SMOKE.

	lb.	oz.
Powder, L.G., bruised	5	0
Saltpetre, pulverised by evaporation .	1	0
Coal, Sea, pounded	1	8
Pitch, Swedish	2	0
Tallow, Russian	0	8

Burn about 4 minutes.

CROSS-HEADED TUBES.*

Detonating Composition.

	lb.	oz.	dr.
Potash, Chlorate of	0	6	0
Antimony, Sulphide of . . .	0	6	0
Glass, ground	0	1	10

Damped with spirits, methylated, 1 quart, and shellac 357 grains, in the proportion of 75 minims to 1000 grains of composition.

COPPER FRICTION TUBES.

Detonating Composition.

	lb.	oz.
Potash, Chlorate of	0	6
Antimony, Sulphide of	0	6
Sulphur, sublimed	0	0½

Damped with spirits, methylated, 1 quart, shellac 824 grains, in the proportion of 200 minims to 1000 grains composition.

QUILL FRICTION TUBES.

Detonating Composition.

	lb.	oz.
Potash, Chlorate of	0	6
Antimony, Sulphide of	0	6
Sulphur, sublimed	0	0½
Powder, mealed	0	1

Damped with spirits, methylated, 1 quart, and shellac 448 grains, proportion 200 minims to 1000 grains of composition.

* *All Tubes are gauged to two-tenths of an inch diameter.*

ELECTRIC TUBES AND FUZES.

	lb.	oz.
Copper, sub-sulphide of		
Copper, sub-phosphide of		
Potash, Chlorate of		

PORTFIRES.

PORTFIRE, COMMON.

	lb.	oz.
Saltpetre, ground	6	0
Sulphur, sublimed	2	0
Powder, mealed, cylinder.	1	4

Length, 16 inches.
Will burn 13 minutes.

PORTFIRE, BLUE, OR SLOW.

	lb.	oz.
Water, distilled, from one to two quarts according to the nature of the paper.		
Saltpetre, ground	0	3

PORTFIRE, MINERS'.

	lb.	oz.
Saltpetre, ground	4	0
Sulphur, sublimed	2	0
Powder, mealed, cylinder.	2	0

PORTFIRES, COASTGUARD, AND SLOW-BURNING COMPOSITION FOR LIFE-BUOY PORTFIRES.

	lb.	oz.
Saltpetre, ground	8	0
Sulphur, ground	4	0
Powder, mealed, cylinder	1	0

PORTFIRES, LIFE-BUOY.

Quick-burning Composition.

	lb.	oz.
Saltpetre, ground.	3	0
Sulphur, sublimed	2	0
Powder, mealed, pit	1	0

LIGHTS, LONG AND SIGNAL.

	lb.	oz.
Saltpetre, ground.	7	0
Sulphur, sublimed	1	12
Orpiment, red.	0	8

Long light burns 5 minutes. Signal light burns 1 minute.

MATCH, SLOW.

Hemp Yarn, pure, Russian . .	lbs. 100
Ashes, Wood	bushel 1
Water	gallons 50

One yard burns about 8 hours. One skein (35 yards) weighs 7 lbs.

MATCH, QUICK.

	4 Threads. lb. oz.	6 Threads. lb. oz.	10 Threads. lb. oz.
Cotton Wick	1 10	2 2	2 7
Gum, Arabic	0 8	0 9	0 10
Powder, mealed, cylinder .	20 0	20 0	24 0
Water, distilled . . .	8 pints.	9 pints.	10 pints.

FUZES, TIME, WOOD, BOXER.

Of general service. Heads closed with metal. 20 seconds, and 9 seconds B.L.R.O. fuzes have detonators for ignition. M.L.O. fuzes are ignited by Quick match through the head, exposed before firing. Also Special—10 seconds M.L.O. for 7 Pr.

"E" Time, Freeth's Modification; and C Percussion, Freeth's Modification. The former screws into B.L. Field Service Shell, the latter drops into the Segment shell, or into a special socket in common shell.

FUZE (BOXER'S).

The wooden cases are made of well-seasoned beech. The composition bore is made excentric with regard to the exterior, and two powder channels are bored upon that side in which there is the greatest thickness of wood. A hole is bored through the mealed powder at the top, and into the fuze composition, to insure the ignition of the fuze composition from the priming. Two rows of holes (the holes two-tenths of an inch apart) are made into the powder channels, and the bottom hole in each row is continued to the axis of the composition bore. The small side holes, with the exception of the bottom ones, are filled with pressed powder and a small portion of clay. The powder channels contain rifle powder, and the bottom side holes have a piece of quick match placed in them.

A simple boring bit is supplied to each gun, in case the borer, specially made for the fuze, is lost or damaged.

Colonel Boxer's fuzes are adopted for all natures of guns, and howitzers, one inch in length for diaphragm shells, and two inches in length for common shells, 3 inches for 5½, and 4⅖ inch mortars.

FUZE, MORTAR, LARGE (BOXER'S).

Fuze for 13, 10, *and* 8 *inch Mortar* Shells.

The fuze for mortar shells has a spiral row of holes, the centres of *which are* ·2 *of an inch* apart in the direction of the axis of the fuze.

Directions for preparing the Fuze for any particular range.

Hold the fuze firmly in the left hand, insert the point of the bit into the required hole, place the head of the brace against the body, and turn with the right hand until the stop comes in contact with the wood.

N.B.—The wood bottom of the fuze must on no account be cut off, as it supports the composition, and prevents its being disarranged by the shock at the discharge.

FUZE.

Composition.

	lb.	oz.
Saltpetre, ground	3	4
Sulphur, sublimed	1	0
Powder, mealed, pit	2	12

PETTMAN LAND, SEA, AND GENERAL SERVICE FUZES.

Detonating Composition.

Potash, Chlolate of	parts	12
Antimony, Sulphide of . . .	„	12
Sulphur, sublimed	„	1
Powder, mealed, L.G. . . .	„	1

Damped with varnish, of spirits, methylated, 1 pint, and shellac 112 grs., in a proportion of 40 minims to 100 grs. of compo.

E-PATTERN FUZES.

Detonating Composition.

Phosphorus, Amorphous, with 10 per cent. calcined magnesia . . .	parts 8
Potash, Chlorate of	„ 16
Shellac	3 oz. 8 gr.
Spirits, methylated	gill 1
Glass, ground	parts 6

40 minims of varnish to 90 grs. compo.

TIME FUZE, BOXER 2-INCH.

Detonating Composition, Rifled Ordnance.

Potash, Chlorate of	parts 6
Antimony, Sulphide of	„ 4
Mercury, Fulminate of	„ 4

Damped with varnish, of spirits, methylated, 1 pint, shellac 645 grs., in a proportion of 24 minims to 100 grs. of composition.

DYER PERCUSSION FUZE.

Detonating Composition.

Same as for E-pattern, with addition of ¾-gill of spirit, methylated.

PILLAR FUZE.

Moorsom Detonating Composition.

	lb.	oz.
Antimony, Sulphide of (between 80 and 120 mesh)	0	6
Potash, Chlorate of	0	6

Damped with thin varnish, of spirits, methylated, 1 pint, shellac 645 grs., in the proportion of 32 grs. to 100 grs. composition.

METFORD EXPLOSIVE BULLET.

	lb.	oz.
Potash, Chlorate of	0	2
Sulphur, sublimed	0	1

COMMON, OLD PATTERN, PERCUSSION CAPS.

	lb.	oz.
Mercury, Fulminating	0	4
Potash, Chlorate of	0	6
Glass, ground	0	2

H.P. CAPS (FOR BREECH-LOADERS ONLY).

	lb.	oz.
Mercury, Fulminating	0	4
Potash, Chlorate of	0	1

COMPOSITION FOR PRESENT PATTERN, A/64.

	lb.	oz.
Mercury, Fulminating	0	6
Potash, Chlorate of	0	6
Antimony, Sulphide of	0	4

CONGREVE ROCKETS.

	24 Pr.		12 Pr.		6 & 3 Pr.	
	lb.	oz.	lb.	oz.	lb.	oz.
Saltpetre, pulverised . .	7	12	8*	12	8	12
Sulphur, sublimed . . .	2	0	2	0	2	0
Charcoal, Alder, ground .	3	0	2	14	2	8

BOXER IMPROVED ROCKETS.†

	24 Pr.		12 Pr.		6 Pounder. Quick.		6 Pounder. Slow.	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
Saltpetre, pulverised . .	62	0	62	0	68	12	62	0
Sulphur, sublimed . . .	16	0	16	0	12	4	16	0
Charcoal, Alder, ground .	24	0	24	0	18	12	24	0

* *12 & 24 Pr.* **Hales Rocket.**
† *Quick composition.*

HALES ROCKET.

	6 & 3 Pr. lb.	oz.
Saltpetre, pulverised	68	12
Sulphur, sublimed	12	4
Charcoal, Alder, ground	18	12

SIGNAL ROCKET.

	lb.	oz.
Saltpetre, pulverised	8	0
Sulphur, sublimed	2	0
Charcoal, Dogwood	3	0

STARS OF SIGNAL ROCKETS.

Composition for.

	lb.	oz.
Saltpetre, pulverised	8	0
Sulphur, sublimed	2	0
Antimony, Sulphide of	2	0
Isinglass	0	3½
Spirits, methylated	pint	1
Vinegar	quart	1
Powder, L.G., mealed, for priming	pound	1

Head of 1 lb. Rocket contains 36 Stars.
" ½ lb. " 24 "

LABORATORY STORES, ETC.

ADAPTERS. RIFLED GUNS.

General Service, Gun metal. Used to make shells, with the "Moorsom" gauge, take fuzes of the General service gauge. There are two patterns, one for Rifled shell, and one for Naval smooth bore Shell.

GREASE.

The composition used for greasing wheels is composed of equal parts of Tallow, and coarse sweet oil melted together; and is made up in kegs of 28 lb. each. In warm weather the proportion of tallow must be increased.

GUNPOWDER.

The component parts of Powder are 75 parts of nitre, 10 of sulphur and 15 of charcoal.

Cylinder Powder is made from charcoal that has been burnt in iron *cylinders;* and *Pit powder* from charcoal burnt in common pits.

Gunpowder, when ignited, expands with a velocity of about 5,000 *feet per second;* and the pressure of the fluid is about 2,000 times *that of* common air.

One pound of powder measures 32 solid inches.

A cubic foot of Government powder weighs about 58 pounds.

Gunpowder is manufactured by reducing the nitre, sulphur, and charcoal to powder; they are then mixed, moistened with water, and again mixed in a mill for five or six hours, or until the mixture is as intimate as possible, for upon this the strength of the powder chiefly depends.

When taken from the mill, the composition is put in a press, and formed into hard cakes about a quarter of an inch thick; these, when dry, or nearly so, are broken by wooden mallets into small pieces, and reduced into grains by being put into sieves, and forced by means of a wooden roller through circular holes of the proper diameter.

Good powder should be devoid of smell, and of uniform colour, approaching to that of a slate. The particles should be perfectly granulated, and free from cohesion. It should admit of being readily poured from one vessel to another.

In powder that has become damp, large lumps are formed: should the damage, however, not be very considerable, these concretions may be reduced by drying the powder in a hot-air stove, rubbing and loosening the grains; but powder thus affected never thoroughly regains its lost strength.

To test the purity of powder.—Lay a dram of it on a piece of clean writing-paper, and fire the heap by means of a red-hot iron wire: if the flame ascend quickly with a good report, leaving the paper free from white specks, and without burning holes in it, the goodness of the ingredients, and proper manufacture of the powder may be safely inferred.

Good powder blasted upon a clean plate of copper should leave no track or mark of foulness.

Powder exposed for 17 or 18 days to the influence of the atmosphere ought not to increase materially in weight. One hundred pounds of powder should not absorb more than twelve ounces: if it increase in weight more than one per cent., the powder should be condemned.

POWDER MARKS.

The various sorts of powder are distinguished by the following marks on the heads of the barrels:—

*L G . . . . Large grain.
*F G . . . . Fine grain.

* *Red* L G, or F G, denotes powder of the best quality. † *White* L G, or F G, is an inferior powder for salutes, &c.

POWDER MAGAZINES.

To ascertain if a Magazine is damp.—Soak a piece of sponge in a solution of salt of tartar, or common salt and water: let it be well dried, and weighed, and then be placed in the magazine, which, if damp, will cause the sponge to become heavier.

A small weight, suspended by a piece of catgut, or hair, will also

discover moisture, causing the former to contract, and the latter to lengthen.

POWDER BARRELS.

Whole Barrels contain 100 lb., and Half Barrels 50 lb., of powder, whether fine, or coarse.

Dimensions of Powder barrels.

	Whole barrels. inches.	Half barrels. inches.	Quarter barrels. inches.
Depth	21·1	16¾	14
Diameter at top . .	15·4	12¼	9½
Do. at bulge . .	17·4	13¼	10¼
Do. at bottom . .	15·4	12¼	9½

BUDGE BARRELS.

Weight of barrel, copper-hooped, 10 lb., hazel-hooped, 6 lb.

Length of barrel 10½ inches }
Diameter . . 13 „ } each barrel will contain 38 lb.

CASES, POWDER (BOXER'S).

Pentagonal.—*Dimensions of sides in inches.*

One—15·42. Two—11·044 Two—9·2. Depth of case—19·2.
Weight, 68 lb.

HYDROSCOPE.

Instrument for measuring distances from elevated batteries.

It consists of a galvanized iron tube about 8 ft. 9 in. long, with a copper cistern at each end. Each cistern contains a zinc float carrying a straight edge on a wire, the stalk being 7 inches high, and having a small steadying weight at the bottom. The tube is let into a groove cut in a block of wood, and is secured to it by an iron plate which is screwed down to the block. To the side of one of the cisterns is attached a brass socket in which a wooden tangent scale slides, and may be clamped at any height. Two faces of this scale are graduated in yards, each face for a separate height above the level of the sea.

The instrument is used as follows:—

A sufficient quantity of water having been poured in to fill the tube and cisterns so far as to support the floats, the block of wood carrying the tube is placed upon the parapet or other convenient resting place, and the tube directed towards the object the distance of which is to be ascertained.

From the arrangement of the floats, the straight edges which they carry are always on the same level, no matter what may be the inclination of the tube. The tangent scale being then raised until the object is seen through the + slit of the sight in the same line as the further straight edge, the distance on the scale which coincides with the nearer straight edge is the approximate distance of the object.

MANTLET, IRON.

Iron Mantlets for the protection of Markers at Rifle practice are constructed of half-inch plate iron, 7 feet 4 inches high, 6 feet long, and the sides 1 foot 6 inches wide at the top, and 2 feet 6 inches at the bottom. Weight 17 cwt. The mantlet is secured by four screws on each side, which pass through angle, riveted to the mantlet, into wooden baulks underneath.

PASTE.

	lb.	oz.
Flour	2	0
Alum, pounded	0	1
Water	1	gall.

SHELLAC PUTTY.

	lb.	oz.
Whiting	6	0
Shellac, Gum	2	0
Spirits, methylated	1	quart.

THICK BROWN VARNISH.

	lb.	oz.
Shellac, Gum	16	0
Spirits, methylated	2	galls.

THIN BROWN VARNISH.

	lb.	oz.
Shellac, Gum	8	0
Spirits, methylated	2	galls.

PENDULUMS.

A Pendulum is readily made (if not in store) with a musket ball, and a piece of silk. The length of a pendulum is measured from the centre of the ball to the end of the loop, on which it swings.

Length of Pendulums to vibrate	Seconds	39·14 inches.
	½ Seconds	9·8 „
	¼ Seconds	2·45 „

To find the length of a pendulum to make a given number of vibrations.

Rule.—As the square of the given number of vibrations is to the square of 60, so is the length of the standard (39·14, length for one second) to the length sought.

Or, multiply 39·14 *by the* square of the time required for the *pendulum to vibrate—viz., by* the square of $\frac{1}{2}=\frac{1}{4}$, for ½ second; and *by the square of 2=4, for two seconds.*

To find the number of vibrations, the length of pendulum being given.

Rule.—Multiply 60 seconds by the square root of 39·14, divided by the length of the given pendulum.

Or say, As the given length is to the standard length, so is the square of 60 (its vibrations per minute) to the square of the number required.

ROCKETS, WAR.

Two kinds—1st. Boxer's improved Congreve. 2nd. Hale's. Of both there are 3, 6, 12, 24 pounders. Hale's rocket has no stick, being kept point foremost by the aerotation given from the gas pressing against 3 curved shields fixed to the three vents.

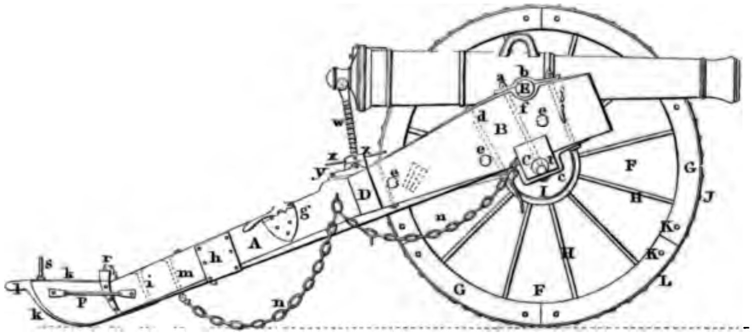
ROCKETS, LIFE SAVING, BOXER 12 POUNDER.

These are fixed to carry a line over a stranded vessel, and establish a communication by means of which a hawser carrying a sling, and also a line for running the sling along the hawser are made fast to the highest possible point available on the masts. Two or three men may travel together on the sling. No rule can be given as to speed, which must depend on the distance of the vessel. It is very important to avoid fouling.

MACHINE, ROCKET.

For Congreve rockets there are three kinds—1. Siege. 2. Field. 3. Sea-service. Some modifications will be adopted for Hale's rockets.

ELEVATION OF A 9 P^R. BRASS FIELD CARRIAGE.



PART IV.

ARTILLERY EXERCISES.

PART I.*—*Telling off the Detachments.*

1. In the service and exercise of the various descriptions of ordnance, the same numbers, as far as possible, always perform the same duties; the detachments being told off upon the same principle, viz., beginning with the lowest numbers, and proceeding to the highest; No. 1 always commanding.

2. It is presumed that not less than six men will be posted to any description of ordnance. When the detachment consists of less than six men, the higher numbers are struck out and additional duties are imposed on those remaining.

3. The detachment falls in, two deep, in close order, No. 1 tells them off from the right; 2 being the right hand man of the rear rank; 3 the right hand man of the front rank; 4 the second man from the right of the rear; 5 the man in his front, and so on. The detachment is also told off into two sections.

NAMES OF THE PRINCIPAL PARTS OF A FIELD GUN CARRIAGE.

A Block, or Trail.	G Felly.
B Cheeks, or Brackets.	H Spokes.
C Axletree.	I Nave.
D Ogee.	J Tire, or Streak.
E Trunnion holes.	K Rivets.
F Wheel.	L Tire, or Streak bolts.

a Eye, or Capsquare bolts.	n Locking chain.
b Capsquares.	o Breast, or advancing chain.
c Axletree bands.	p Trail handles.
d Bracket bolts.	q Handspike shoe.
e Transom bolts.	r Handspike pin.
f Trunnion plates.	s Handspike ring.
g Portfire clipper.	t Axletree arms.
h Locking plate.	u Dragwashers.
i Trail plate bolt.	v Nave hoops.
k Trail plate.	w Elevating screw.
l Trail plate eye.	x Handles of elevating screw.
m Chain eye bolt.	y Elevating screw box.

* Extracted from "MANUAL OF ARTILLERY EXERCISES;" the Parts and Sections being similarly numbered. Many of the details are necessarily omitted, being too long for the *limited size* of "THE ARTILLERIST'S MANUAL, ETC."

Commander's words are printed in SMALL CAPITALS.
Executive ditto . . . . . *Italics.*

S. 2. *Posts of the Detachment.*

1. *In Action, and before the Word Load.*—No. 1 at the point of the handspike. 2 and 3 outside the wheels; with howitzers rather in rear of the muzzle; with guns in line with the front of the wheel. 4 and 5 in line with the breech. 6 five yards in rear of the left wheel. 7 in rear of the limber. 8 on left of 7. 9 four yards in rear of the limber. The whole facing the gun.

When in action the front is towards the muzzle; when limbered up the front is towards the horses.

2. *In Order of March.*—No. 1 on the off side of the wheel horses' heads. 2 and 3 in line with the muzzle; 4 and 5 in line with the breech; 6 and 7 in line with the axletree of the limber; 8 and 9 in line with the splinter bar. The whole at the distance of one yard from the wheels.

3. *In Front.*—In line ten yards in front of the leading horses; 1 on the right of the detachment.

4. *In Rear.*—In line two yards in rear of the muzzle of the gun; 1 on the right of the detachment.

5. *Right, or Left.*—In line with the gun axletree, one yard to the right, or left of the wheel.

6. *Mounted.*—Nos. 1 and 6 on the gun limber; 1 on the right, 6 on the left. 5 and 4 on the waggon limber; 5 on the right, 4 on the left. 3 and 2 on the front of the waggon body; 3 on the right, 2 on the left. 7 and 8 on the rear of the waggon body; 7 on the right, 8 on the left. 9 between 5 and 4.

S. 3. *Change of Position of Detachments.*

To form the Order of March from Detachment Front.—"FORM THE ORDER OF MARCH." *Right Face, double march.* 2 and 3 open out. Each number halts when at his post; and they front by signal from 2, who faces about immediately he arrives at his station.

2. *From Detachment Rear, or Left, or Right.*—"FORM THE ORDER OF MARCH." *Left face, double march.* When the detachments are in the rear, or on the right they proceed direct; but when on the left they countermarch. Each number halts when at his post.

3. *Change from Front to Rear.*—"DETACHMENTS REAR." *Right face, double march.* When the detachment clears the gun. *Rear turn, right turn, halt, front.*

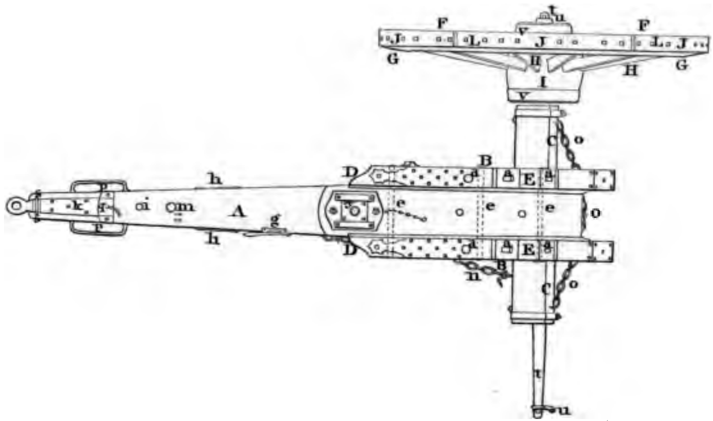
4. *From Rear to Front.*—"DETACHMENTS FRONT." *Right face, double march, front turn, left turn, halt, front.*

5. *From Rear to Right or Left.*—"DETACHMENTS RIGHT," (or left). *Right or left face. Double march, front turn.* When in line with the axletree, *Halt.*

6.—*From the Order of March to form Detachments to the Rear.*—"DETACHMENTS REAR." *Right about face. Double March.* 2 and 3 close to the centre, and wheel to their left. Nos. 1 give *Halt, front.*

7. *To the Front.*—"DETACHMENTS FRONT." Double March.

PLAN OF A 9 P^R BRASS FIELD CARRIAGE.



8 and 9 close to the centre, and when two yards in front of the horses, wheel to the left. Nos. 1 give *Halt, front.*

When No. 1 shifts his flank he moves along the front.

S. 4. Detail of Duties in the Service of Ordnance with Detachments of Different Strengths.

Six Men.—No. 1 commands and lays; 2 sponges; 3 loads; 4 serves the vent; 5 fires; 6 serves ammunition.

Seven Men.—No. 7 attends the limber and serves ammunition to 6, and occasionally changes with him. The other numbers as before.

Eight Men.—No. 8 assists 7 and supplies 6 with ammunition, and occasionally relieves 2. The other numbers as before.

Nine Men.—No. 9 attends the ammunition waggon. The other numbers as before.

PART II.—*S.* 1. *Mounting, and dismounting Field Ordnance with the Materials belonging to the Battery.*

1. The medium 12-pounder requires two gun detachments.

2. The light 6-pounder, and the 12-pounder howitzer, are each mounted by their own detachments. This may also be done with the 9-pounder and the 24-pounder howitzer; but one or two men in addition will greatly facilitate the operation.

3. Nos. 2 and 3 attend to the capsquares and have charge of the muzzle and trunnions; 4 and 5 attend the cascable and chock the wheels of the light guns; 6 and 7 chock those of the heavy; previous to raising the trail, 1 attends to the elevating screw.

4. The carriages are mounted by their own detachments. With the medium 12-pounder, 9-pounder, and 24-pounder howitzer, Nos. 2, 3, 4, and 5 pass a handspike under one of the axletrees, and lift one side of the carriage at a time; 6 and 7 put on the wheels. With the light 6-pounder, and 12-pounder howitzer, 2 and 3 in front, 4 and 5 in rear, lift the carriage at once, 6 and 7 each put on a wheel, 4 and 5 attend to the washers and linch pins in both cases.

5. The limbers and waggons are mounted in the same way. The whole detachment assist in lifting the boxes; after which 2 and 4 strap on the near boxes, 3 and 5 the off boxes of the limbers, 6 the front box, 7 the rear box of the waggon body.

PART III.—*S.* 2. *Exercise with Drag ropes.*

1. A light 6-pounder with its limber requires 20 men, 11 of whom are told off entirely for the drag ropes, the other men at the gun also assisting in manning them; 9 is always in the shafts, and 8 at the point of the shaft (near side). A 9-pounder gun requires additional men, and a double set of drag ropes.

2. The drag-rope men are numbered off from 10 upwards. The even numbers are with the left drag rope; the odd with the right. Nos. 19 and 20 hook the drag ropes on to the splinter bar.

3. The gun being limbered up, the gun detachments man the

ropes next to the gun, the spare men in their front, and stretch the ropes taut.

4. At the word "Action," whether to the *front*, *rear*, *right*, or *left*, the drag ropes are at once quitted; 19 and 20 unhook and coil them up, and the whole of the drag-rope men retire with the limber, forming in front of it two deep, as they were numbered off. In limbering up, the drag-rope men form the order of march, and hook on.

5. The probable manœuvres, with drag-ropes, being of the simplest nature, it is only necessary that the men should be taught how to take ground to the right or left, and reverse, form to the front, &c.

PART IV.—EQUIPMENT OF A BATTERY.

In equipping a battery for the march the intrenching tools, camp equipage, &c., are packed as follows:—

On Gun Limber.—Two carbines on the front of the boxes, barrels up.
Two fitting ropes on the footboard.
One swingletree between the footboard and the splinter bar.
One felling axe on the splinter bar, edge inwards.
One billhook under the footboard.
A spade or shovel on the side of the boxes, and fastened to the splinter bar.
One grease tin on the front of the axletree.
One pickaxe under the axletree.
One prolonge between the boxes, above the washer box.
Two water buckets on the back of the axletree.
Two corn sacks; two blankets folded (21 inches by 16), on the box lids, the blankets uppermost.

On Gun Carriage. { One claw hammer / One wrench hammer / One pair of pincers } on the cheeks.

One set of priming irons on the side of the trail.
One spare sponge, wadhook, and handspike, under the trail.
Two camp kettles in rear of axletree.

The whole of these stores, &c., are buckled on by Nos. 6 and 7.

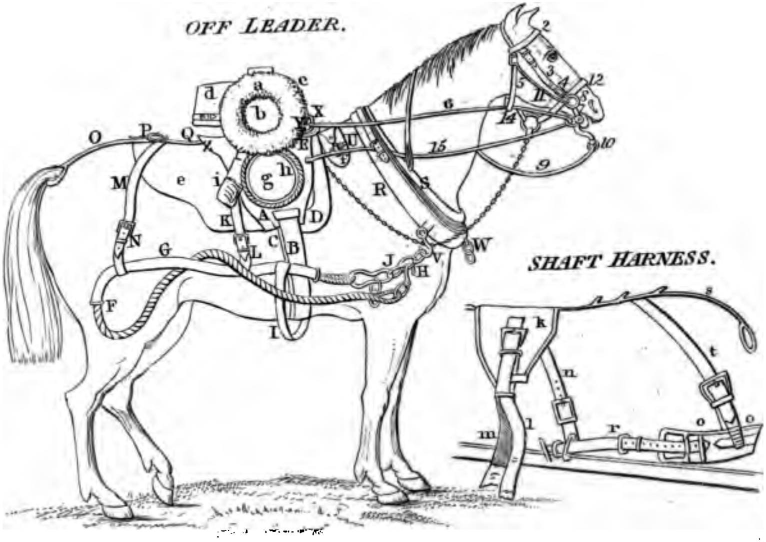
On Waggon Limber.—One picket line on the footboard.
One lifting jack on the footboard.
One grease tin on the front of the axletree.
Two corn sacks, two blankets folded, on the box lids.

These stores are buckled on by Nos. 4 and 5.

On Waggon Body.—Two tents, two bags of tent pins, two tent poles, and two picket posts on each side of the boxes.
One maul, under off end of rear footboard.
Spare horse-shoe box, under the front footboard.
Grease magazine under near end of rear footboard.
Four blankets on the box lids.
One camp kettle on the rear of the axletree.

These stores are buckled on by Nos. 2, 3, 8, and 9.

OFF LEADER.



SHAFT HARNESS.

OFF LEADER

A *Pad or Off Saddle*
B *Surcingle*
C *Girth of the Pad*
D *Pannel of D°*
E *Pad Staples*
F *Trace*
G *Pipe of D°*
H *Hook of D°*
I *Belly Band of D°*
J *Trace Links*
K *Bearing Strap*
L *Buckling Piece of D°*
M *Hip Strap*
N *Buckling Piece of D°*
O *Crupper*
P *Crupper Ring*
Q *Buckling Piece of Crupper*
R *Collar*
S *The Hames*
U *The Housing Strap*
V *Shoulder Link & Hook*
W *Breast Chains or Links*
X *Wither Strap*
Y *Bearing Hook*
Z *Cantle of Pad*
a *Sheepskin*
b *Valise*
c *Baggage Strap*
d *Mess Tin*
e *Numnah*
f *Wallet*
g *Wooden Canteen*
h *Forage Cord*
i *Nose Bag*

THE BRIDLE.

2 *Front or Brow Band*
3 *Cheek*
4 *Cheek Billets*
5 *Throat Lash*
6 *Bearing Rein*
7 *Bit*
8 *Cheek of D°*
9 *Leading Rein*
10 *Bar of the Bit*
11 *Head Collar*
12 *Nose Band*
13 *Collar Chain*
14 *Jowl Strap*. 15 *Side Rein*

SHAFT HARNESS.

k *Pad or off Saddle*
l *Back Band*
m *Shaft Tugs*
n *Bearing Strap*
o *Breeching*
r *Strap of Breeching*
s *Crupper*
t *Hip Strap*

WEIGHT OF CARRIAGES, ORDNANCE, AND APPOINTMENTS.

	12-Pounder.	9-Pounder.	24-Pounder howitzer.	12-Pounder howitzer.	Light 6-Pounder.
	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.	cwt. qrs. lbs.
carriage, limber .	39 2 15	33 1 23	32 3 3	24 2 7	23 3 11
Arms, in-ching tools, . . .	3 14	3 10	2 25	2 23	3 2
munition,&c.	3 3 17	3 3 20	4 3 25	3 3 15	3 2 16
Total . .	44 1 18	38 0 25	38 1 25	29 0 17	27 1 1
gon-limber l body, in-ding spare eel . . .	19 1 14	19 0 26	17 0 25	17 0 25	18 2 26
es, intrench-g tools, spare rse-shoes,&c.	4 0 7	4 0 7	4 0 7	4 0 7	4 0 7
munition .	11 3 26	10 3 16	12 0 5	10 1 9	10 2 8
Total . .	35 1 19	34 0 21	33 1 9	31 2 13	33 1 13

9-pounder with 6 horses can, without distressing the horses, march about four in an hour and a half, eight miles in four hours, and sixteen miles in ten hours.

RANGES, &c., OF FIELD ARTILLERY.

Nature of Ordnance.	Charge.		Weight.		Elevations, and Times of Flight.																									
					Point-blank.	Seconds.	½	Seconds.	1	Seconds.	1½	Seconds.	2	Seconds.	2½	Seconds.	3	Seconds.	3½	Seconds.	4	Seconds.	4½	Seconds.	5	Seconds.	5½	Seconds.	6	Seconds.
	lbs.	oz.	cwt.	qrs.																										
6-pounder Gun	1	8	6	0	336	·8	468	1·4	643	2·	763	2·4	926	2·9	1,019	3·4	1,070	4·	1,202	4·4	1,100	4·6	1,280	4·9	1,416	5·5	1,501	5·9	1,600	6·6
9-pounder Gun	2	8	13	2	311	·6	490	1·4	688	2·	806	2·4	955	2·8	1,052	3·5	1,148	4·2	1,293	4·5	1,475	5·2	1,519	5·6	1,541	6·	1,631	6·5	1,781	7·
12-pounder Howitzer	1	4	6	2	199	·7	309	1·	404	1·3	527	1·9	625	2·1	721	2·7	776	3·5	881	3·8	1,022	4·3	1,031	4·4	1,126	5·	1,210	5·4	1,293	6·
24-pounder Howitzer	2	8	13	0	273	·8	393	1·2	515	1·7	661	2·2	785	2·7	873	3·3	941	3·7	1,111	4·2	1,208	4·6	1,258	4·8	1,381	5·6	1,459	5·9	1,485	6·

HEAVY GUN DRILL.

PART I.—ELEMENTARY INSTRUCTION IN MOVING HEAVY ORDNANCE.

ARTICLE III.—TACKLES, AND PURCHASES.

A simple tackle consists of one or more pulleys rove with a single rope.

The rope is termed a "fall." The pulleys are called "blocks." The shell or frame contains the sheaves of the pulley, which turn on a pin.

When a tackle is in use, one end of the fall is made fast; the other is hauled upon.

The fixed end is called the "standing end of the fall." The other the "running end."

Each separate part of the fall contained between two blocks, or between either extremity and a block, is called "a return of the fall."

To *overhaul* a tackle is to separate the blocks.

To *fleet* blocks is to bring them as close together as possible by hauling on the fall.

Wooden blocks are generally bound on the outside, in the direction of their length, with a grummet, which is called "the strap" of the block.

If the strap be continued, so as to form a tail, at the end of the block which has no hook, the block is called a tail or jigger block; and if a tackle have its moveable block so furnished, it is called a "jigger tackle."

Bothway's patent blocks are now frequently used. They are iron strapped, the strapping passing inside the shell, and affording a better support to the pin, upon which the sheave turns, than the ordinary block does. In consequence of the pin being better supported, it is of less diameter than in the ordinary block, and consequently offers less resistance to the turning of the sheave. These blocks are fitted with swivel-hooks. The iron strapping is retained in its place by means of the pin.

It is essential in working blocks that the pin be well lubricated with oil.

The following are the principal points to be attended to in the arrangement and use of tackles, viz.:

(1) The condition, and consequent strength of the straps, hooks, and cordage.

(2) That the fall is free from kinks and turns, and enters freely into the grooves of the sheaves.

(3) The nature of the fastenings of every kind, which should be such as to insure perfect security if possible.

(4) The proper stoppering of the fall, when necessary. This is effected by making fast the fall to some fixed object, at a point intermediate between the running and standing ends.

(5) The prevention of accidents from the carelessness of the men in striking or treading upon the fall, especially when it is taut.

(6) The position of the men, which should be such as to insure the greatest amount of safety to themselves, in the event of accident, consistent with the due performance of their work.

The most advantageous application of a man's power in hauling is in a slanting direction downwards, as the effect of his weight is added to that of his muscular exertion.

It not unfrequently happens, when a weight is to be moved, that, from the nature of the ground, or other unavoidable circumstances, the men employed in the operation cannot apply their strength immediately in the direction in which it would be most effective. In such a case, a single pulley is made fast to a point in the direction in which it is intended that the weight shall be hauled upon. A rope is made fast to the weight, and passed round the sheave of the pulley; and the men then haul in any direction that may be most convenient. The friction of the rope against the pulley diminishes the effective power in so small a degree, as to be of little or no consideration.

A single block, so fixed, and for such a purpose, is called "a leading block."

A single fixed pulley, when rove, is likewise called a whip.

The following are the tackles commonly used in the service of artillery:—

(1) "A whip," or single moveable pulley, which doubles the effect of the power.

(2) "A gun tackle" increases the effect of the power threefold. It consists of two single blocks, one of which is moveable and the other fixed. The standing end of the fall is made fast to the moveable block.

(3) "A luff tackle" increases the effect of the power fourfold, and consists of a double and single block, the double block being the moveable one. The standing end of the fall is made fast to the single block.

(4) "A whip upon whip" increases the effect of the power fourfold. It consists of two moveable pulleys, one of which is applied to and acts upon the running end of the fall of the other. There is less friction in this combination than in a luff tackle, but it is not always convenient to apply it; it is used in running back at drill.

(5) "A gyn tackle" increases the effect of the power five times. It consists of a double and triple block. The standing end of the fall is made fast to the double block, which is moveable. For the heaviest guns two triple blocks are preferable, and a power of 6 is gained. The tackle is rove by Nos. 10 and 11.

Other combinations of pulleys are occasionally used, the values of which depend upon their particular natures. The increase of effect *produced* by any particular simple tackle, is represented by the sum of *all the returns of* the fall which act *immediately* upon every moveable *block in it.*

In a combination of "tackles," where one acts upon the running end

of another, the result of their combined action is found by multiplying together the values of the several simple tackles.

A luff tackle applied to the end of a large rope rove through a single block is called a runner tackle.

The increase of power attributed to the foregoing systems of pulleys is correct only upon the supposition that there is no friction of the rope against the sheaves and blocks. In practice, the friction is found to be very great; so great, indeed, that no more than two triple blocks can be used with effect in the same tackle. In many operations of artillery, however, friction is of great use, inasmuch as it enables a small force, acting at one end of a rope, to sustain a great weight acting at the other, if the precaution be taken to pass a few turns of the rope round a fixed object of suitable strength, as a tree, a picket, the axle of a windlass, &c., &c. The effect of friction increases, in proportion to the extent of surface over which it acts; consequently, a greater number of turns must be taken round a small object than round one of larger dimensions.

It is to be borne in mind that the use of tackles, levers, and other mechanical contrivances, affords an increase of power, only at the expense of time. If one man, by means of a tackle, can raise a weight which it would require ten men to lift by sheer muscular strength, he will likewise occupy ten times as much time in the operation. In addition to the loss of time in the actual operation, that caused by the preparation and adjustment of the mechanical contrivance made use of, has also, in many cases, to be considered.

A *wheel purchase* is formed by hooking a drag-rope to the tire of a wheel as near the ground as possible, carrying the running end up over the tire, and stretching it out so as to form a tangent to the wheel; when the rope is hauled upon the carriage advances. The power gained is in proportion to the diameter of the wheel.

The recruit must be taught how to reeve all the tackles named. The men stand in pairs, back to back, when reeving all simple tackles; the blocks are to be in front of them, the tackle coiled in a convenient position near them on their right, or left, according as the reeving is from right to left, or left to right.

ARTICLE IV.—LEVER, AND HANDSPIKE.

The lever used in the ordinary operations of artillery is termed a handspike; it is 6 feet long, and 3½ inches square at the *point* or large end. In the service of the heavier guns a 7 feet handspike is used.

The greater the length of the lever the greater is its power.

A man using a lever should always apply his strength as near the end of it as he can.

When the weight to be moved is at one end, and the fulcrum, or body on which the lever is supported, is between both, the lever is said to be "*of the first kind.*"

When the fulcrum is at the end and the weight at an intermediate *point, the lever is said to be "of* the second kind."

Although the entire implement is called a lever, that part of it which is between the power and the fulcrum is more particularly so called.

That part which is between the weight and the fulcrum is called the "counter-lever," thus:—

In running up a heavy gun on a standing carriage, the whole of the handspike constitutes the lever, and the part between the point and the axletree arm the counter-lever.

Fulcrums.

Any piece of strong timber of suitable dimensions may serve for a fulcrum. The term fulcrum means a support for a lever.

Props.

Props are used as temporary supports for a waggon, carriage, skid, &c.

Slewing.

To slew a gun, or mortar, strictly speaking, is to turn it on its axis without moving it from the spot on which it rests. This is called slewing the trunnions.

If the piece to be slewed rests on skids, a handspike is placed close to it on each skid, bevel up, and on that side of it towards which it is to be turned. This is called scotching, or chocking, and the handspikes are called "chocking handspikes."

Pinching.

Pinching is the operation of moving a gun, or mortar, by small heaves of the handspike, without allowing it to turn on its axis. It is moved little by little, and rubs against the skid on which it rests.

Cross Lifting.

To cross lift a gun, or carriage, is to move it in a direction nearly at right angles to its axis.

When one long lever is used, it is applied alternately under the breast and rear of the carriage, or muzzle and breech of the gun, as the case may be, by a sufficient number of men to bear down and heave, as in rowing.

Parbuckling.

To parbuckle a gun is to roll it so as to cause it to move in either direction *from* the spot on which it rests. For this purpose, the gun must be placed on skids, and, if it is to be moved up or down a slope, two 4½-inch ropes must be made fast to some suitable object on the upper part of the slope, the ends carried under the chase and breech of the gun respectively, round it and up the slope. If the running ends of these ropes are hauled upon, the gun ascends; if eased off, it descends.

If the ground is horizontal, handspikes only are necessary to move the gun.

If the slope is not great, one rope will suffice to parbuckle a gun up with. In this case, it must be made fast to one of the trunnions, and passed as many times round the gun, in rear of and close to them, as may be convenient, the running end coming out as before over the gun and up the slope. In hauling the gun up, the rope uncoils itself. The breech end of the gun, on account of its greater thickness, will always advance quicker than the muzzle.

ARTICLE V.—LIFTING JACK.

The lifting jack forms part of the equipment of every battery and battering train. It may be applied to many of the purposes for which a long lever is used; but it is commonly employed to raise the wheels of carriages from the ground when they are to be greased, or exchanged, and to extricate them from ruts and holes.

The wheel opposite to that which is to be raised must be scotched.

On soft ground a piece of plank must be placed under the foot of the jack, to prevent its sinking.

The tooth and pinion, and screw jacks may be employed to move bodies horizontally, a few inches, provided a good support can be found for the foot of the stock. By the application of two jacks in opposite directions, bodies may be brought together to be spliced, riveted, &c.

ARTICLE VI.—ROLLERS.

Rollers are solid cylinders of wood, used in mounting guns upon their carriages, in shifting them from carriage to carriage, and in moving them on the ground. Their dimensions vary according to the nature of the service for which they are intended.

They can be used with advantage, only on a perfectly plane and hard surface.

When a gun is moved on rollers, they must be horizontal, or it will roll off them; and even when the rollers are horizontal, steadying handspikes should be applied, to guard still further against such an accident.

The rollers must be placed at right angles to the direction in which they are intended to move, projecting equally on each side of the axis of the gun, or other body, which they support.

A gun laid upon rollers may be moved, either by hauling upon it with ropes, or by means of levers.

ARTICLE VII.—CRAB CAPSTAN, AND TEMPORARY WINDLASS.

A crab capstan consists of a barrel (in shape a frustrum of a cone), and a framework of wood and iron by which the barrel is supported in a vertical position with its base next the ground. It is furnished with two levers, called capstan bars, which are passed through mortices in the head, and by means of which the barrel may be turned about on its axis. By means of the crab capstan, a few men, acting at the bars, can

move weights which would be far beyond their strength, if applied in the ordinary manner; and it may, therefore, be used with advantage in many situations, in which it may be either difficult to command labour, or desirable to economize it.

One end of a rope is made fast to the weight which is to be moved. The other end is passed two or three times round the lower part of the barrel, the loose end being kept above the turns, and stretched taut by the man who passed it round. As the barrel is turned, the rope winds round it, forces the turns up the barrel, and clears itself. As fast as the running end comes off the barrel, it is coiled by a man appointed to that duty.

The capstan when used, is secured by ropes to pickets, or other holdfasts on the opposite side of it to that on which the strain acts upon it.

If a crab capstan cannot be procured, the windlass of a gyn may be used as a substitute, the cheeks being laid on the ground and secured with pickets; or a temporary capstan may be rigged, by lashing four handspikes to the spokes and felloe of a limber wheel, which is turned upon the pintail of the dismounted limber.

PART II.—SERVING, AND WORKING HEAVY ORDNANCE.

ARTICLE I.

A gun detachment consists of one non-commissioned officer and nine gunners.

"Telling off." The men fall in, on their private parade, two deep, the non-commissioned officer gives the word "Tell off." The men are told off as with field guns.

The detachment is marched into the battery, and is halted in line, facing the parapet, and to the left rear of the gun which is to be worked. The detachment is now in the position of "Detachment rear," or that which it occupies when it comes into the battery as a relief, and whilst the relieved party is marching off.

GENERAL DETAIL OF DUTIES FOR DETACHMENTS OF TEN MEN AT ALL HEAVY GUNS.

No. 1 points, and commands.

No. 2 searches, sponges, rams home, elevates.

No. 4 clears the vent, serves it, pricks cartridges, traverses.

No. 6 supplies side arms to No. 2, cleans spunge if necessary, attends stool bed, elevating screw and quoin in laying, has charge of water buckets, assists to load the *8-inch, 10-inch*, and 68-pr. guns, *and also hot* shot, with all calibres.

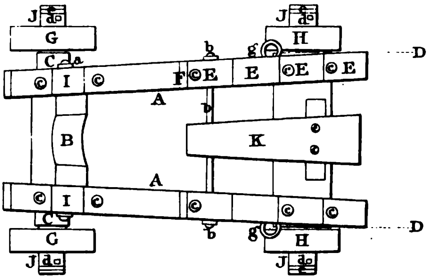
No. 3 loads, assists to ram home, elevates, uncaps fuze when in bore.

No. 5 serves No. 3 with projectiles, wads, if necessary, and traverses, attends stop quoins with 8″ and 10″ howitzers.

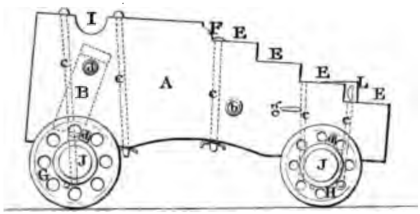
No. 7 serves No. 3 with cartridge, primes, and fires.

The above numbers run the gun up.

PLAN OF A GARRISON CARRIAGE.

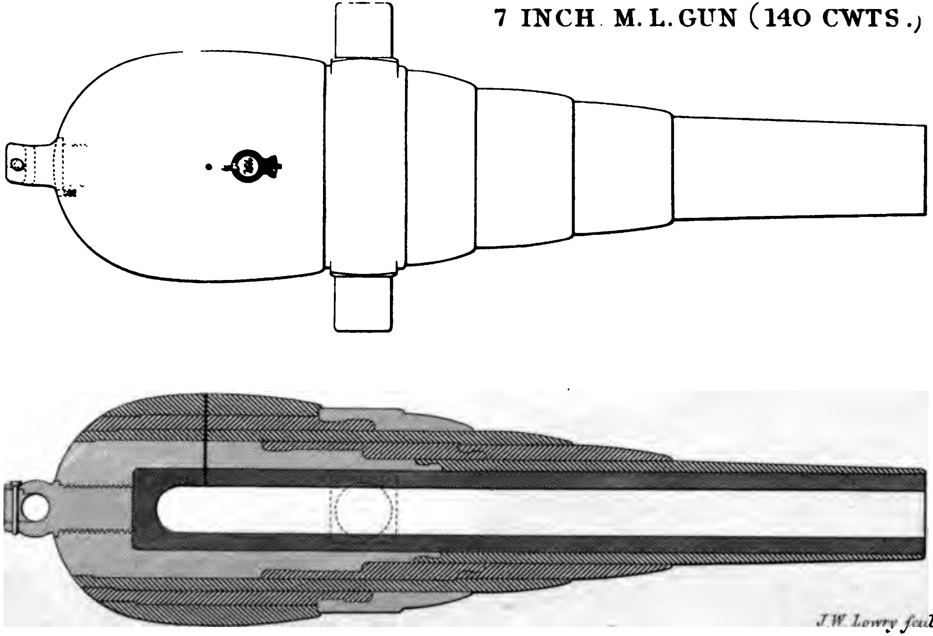


A *Sides or brackets*
B *Transom*
C *Fore axletree*
D *Hind axletree*
E *Steps*
F *Quarter round or ovolo*
G *Fore truck*
H *Hind truck*
I *Trunnion hole*
J *Axletree arm*
K *Stool bed*
L *Quoin*
a *Transom bolt*
b *Bed bolt*
c *Bracket bolts*
d *Linch pins*
e *Axletree hoops*
f *Stool bed bolts*
g *Eye or loop bolts*



ELEVATION OF A GARRISON CARRIAGE.

7 INCH. M. L. GUN (140 CWTS.)



J. W. Lowry sculpt.

No. 8 assists to prepare shells, and to supply gun with projectiles, and spare stores when necessary. Brings up cartridges from magazine.

No. 9 bores and fixes fuzes, assists to prepare and bring up projectiles.

No. 10 attends to the magazine, serves out cartridges to No. 8, and performs the general duties of storeman.

Besides the men told off as above some will be required to move powder barrels, rivet on bottoms, load shells, heat shot, &c.

GENERAL LIST, AND PLACE OF STORES REQUIRED FOR SERVICE OF GUNS ON STANDING CARRIAGES.

Side arms. 1 sponge. 1 rammer. 1 wadhook. } To be placed on the right of the gun, clear of the detachment when under cover. Heads of side arms uppermost, and below the crest of parapet.
When in casemates, or blindages, or when there is no parapet, the side arms must be laid on the ground, parallel to the gun, heads to the rear, and supported to keep them off the ground.

Handspikes. 5, points to the front. } Two on each side of the platform close to the edge of it, front handspikes, or those of No. 2, and No. 3, two feet in advance of those of No. 4 and No. 5. No. 1's handspike in rear of platform.

Priming irons for Garrison guns. Sets 1. In loop on right side of carriage.

Cartridge cases. 2. { One at the gun with a cartridge, the other at the magazine.

Tube pocket, with straps. 1. { Containing tubes, strapped round waist of No. 7.

Fuze implements . . . In shell room.

Key for portable magazine . 1.

No. 4 Set.—One set for two guns, and 25 per cent. spare.

Borers. { Hand. 1. Hook. 1.

Cylinders, wood, containing 6 long, and 6 short bits. 1.

Instructions, printed. 5.

Keys, iron, for fuze hole plugs. 2.

Mallet. 1.

Sections of fuzes. 5.

Setter 1.

Lanyard, with hook. *1. With No. 7.*

Hammers, claw. *1. Ditto,* wrench. 1. With No. 10.

Tangent scales, wood. *1. Stop* quoin. 1. With No. 1.

Shot. Solid or hollow. Grape. Case.	Piled on left of gun, close to front of platform, the round shot enclosed in a large grummet or garland.
Wads, junk, or grummet.	On left of shot, unless the shot are bottomed.
Shells, filled in boxes. Common. Shrapnel.	Either in shell room, or under cover of parapet.

Cartridges filled. In metal lined cases.

Fuzes, Shrapnel „ common.	In boxes in shell room, one per shell.
„ concussion.	One per common shell.
Tubes, friction.	Three for two projectiles. In tube pocket, and zinc cylinders in shell room.
Portfires. Slowmatch.	A small proportion at magazine.

Water bucket. 1. In charge of No. 6.

Grease box		1	In charge of No. 10.
Broom		1	
Shovel		2	
Spade		2	
Pick		1	
Sand bags		6	
Spun yarn	lb.	10	
Lanthorn		1	
Powder horn filled with fine grain powder		1	

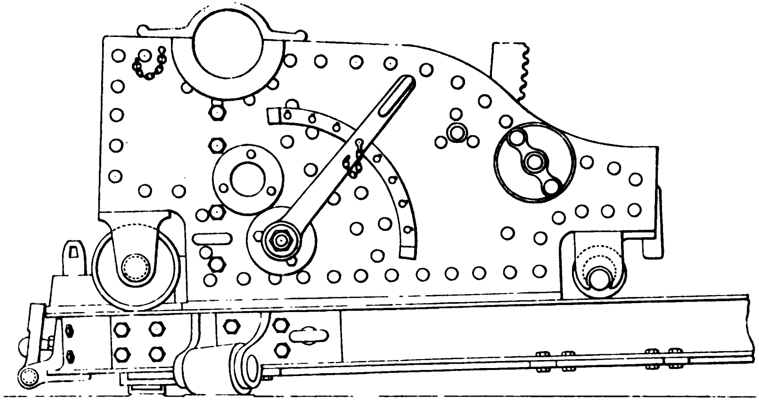
Spikes, common. 1 „ spring. 1	In charge of No. 1.
Spare screws for sights. 4 Wrench for ditto. Shot gauge. 1. Oil, machinery. Tin oil feeder. 1.	In charge of No. 1.

Some articles, such as sponges, rammers, lanyards, handspikes, must also be in excess, the spare stores being in some place in or near the battery. If cartridges are not ready filled, there will be required at the magazine filling funnels, large 1; a set of weights and scales; implements for opening casks; wadmiltilts; slippers; needles; worsted; scissors. Also spare tangent scales; dispart sights; screws, and screw-drivers.

The tangent scale and dispart sight are supposed to have been previously fixed on the gun by competent men. The round, or hollow shot piled on its left, and close to the front of the ground platform, which has a slope of about $\frac{1}{18}$, depending, however, on the nature of the gun, and the service for which it is intended. The axletree arms are greased. The gun is at the tail of the platform. The surface of the platform must be perfectly smooth, and the elevating screw well oiled.

W^{t} IRON NAVAL CARRIAGE AND SLIDE

FOR 7 I^{N} M.L.R. GUN OF $6\frac{1}{2}$ TONS.



J. W. Lowry sculp.

	WEIGHT cwt.	qr.	lb.	TONNAGE tons	ft.	in.
Carriage	27	3	0	1	28	3
Slide	37	1	0	2	15	7

ARTICLE II.—EXERCISE OF GUNS ON TRAVELLING CARRIAGES.

Heavy guns require the following number of men for their service in the field, viz.:

Three Non-Commissioned Officers and thirty men, being necessary on the march for extricating the guns out of difficulties,—taking up positions,—laying temporary platforms,—placing planks under wheels and trail to facilitate working the gun;—and also for affording three reliefs when engaged in siege operations.

In addition to the stores, implements, and side arms for the service of the gun, as before detailed, a heavy gun in the field requires men's harness and drag ropes, a lifting jack, a set of intrenching tools, and three planks of a foot wide, and ten or twelve feet long. There should be luff tackles, lashings, selvagees, levers, fulcrums, and props, for every gun, besides a 16-foot gyn complete, for every four.

The side arms, handspikes, and planks are strapped on the cheeks; the gyn, rollers, tackles, &c., are carried on a platform waggon.

The planks are required for temporary platforms.

Clerk's Platform.

This platform consists of—

Two inclined planes 17 feet long, 12 inches wide, slope 3°.

One front transom $7' \times 16'' \times 4''$ laid flush with surface of ground, to which the inclined planes are pivotted.

Two sleepers, one $7' \times 6'' \times 3''$, the other $8' \times 6'' \times 3''$; these are laid flush with the ground.

One trail plank, $10' \times 16'' \times 4''$. This plank is placed on the ground, so that the trail of a siege carriage may rest on it.

To shift a Gun from the Travelling to the Firing Holes.

The wheels should, if possible, be on a level and scotched.

Words of command.

SHIFT THE GUN.
PREPARE TO RAISE THE BREECH.
BEAR DOWN. LOWER.
PREPARE TO RAISE THE MUZZLE.
LIFT, AND HEAVE.
HALT.
BEAR DOWN.
LOWER.

The operation of shifting from firing to travelling is the converse of this.

ARTICLE III.—EXERCISE OF GUNS ON DWARF, AND CASEMATE PLATFORMS.

The general duties of the detachment are as before described.

Some additional stores are required, viz., two luff tackles, one preventer rope; two truck levers; two shod handspikes, and two scotches; but two common handspikes only are necessary.

At the command PREPARE FOR ACTION, the different numbers bring up the stores as before detailed, and in addition, No. 1 the preventer rope, he passes the eye under the rear transom of the carriage to No. 3, who bolts it to the fore axletree of the carriage; No. 1 then takes two turns round the bollard; Nos. 2 and 3 a truck lever each; Nos. 4 and 5 a shod lever each, and place them parallel to the platform on their respective sides; also a set of luff tackle each; no handspikes; they hook the fixed blocks to the eye-bolts in rear of the platform, coiling up the falls on the ground immediately underneath them. They also provide a scotch each.

ARTICLE IV.—HOT SHOT.

With some few exceptions the duties are the same as those before described.

No. 3 puts a dry wad over the cartridge, and then a damp one.

No. 5 as usual supplies 3 with wads, first a dry, and then a damp one.

Nos. 8 and 9 bring up hot shot on a bearer, in the same manner as they brought up shells.

The sponge must be frequently damped.

The same stores are required as for the service of heavy guns with cold shot. Junk wads are indispensable, and those which are used wet should be of a low gauge. The shot also should be of a low gauge.

Utensils required for Heating the Shot.

One furnace or grate, with chimney in lengths.
One moving tool.
One scraper.
One pair of tongs.
One poker.
One rake.
One shovel.
One stand on which to place the shot in order to scrape them.
One shot bearer per gun.
Two tubs full of water, to soak wads, cool tongs, &c.
Two or three water buckets.
Fuel. Wood, or coals, or a mixture of coal and coke, according to circumstances.
One gauge for shot.

There should never be less than four men to attend the furnace, even when the shot and wood are close at hand, viz., one non-commissioned officer or steady man in charge, to see that the reddest shot are served out and replaced by cold ones, and to keep up such a fire as he may judge necessary.

One man to light and attend the fire, and supply fresh fuel when required.

One to take out shot, lay them on the stand, scrape them, and afterwards place them on a bearer.

One to supply the furnace with cold shot, and to bring fuel.

The shot should not be brought to a white heat, or they may lose shape, and jam in the bore.

Loading.

The cartridge, ¾ths the service charge, must undergo the strictest examination, to see that there are no holes in it, lest in setting it home any grains should fall out. The gun should be slightly elevated.

The gun is then run up, laid, and fired with as little delay as possible.

This furnace will contain in three rows, alongside of each other, fifteen 32-pounder, or eighteen 24-pounder, or twenty-one 18-pounder shot. The shot must be gauged before heating.

To heat the Furnace.

To heat the furnace, it takes of coals half a bushel, of coke 2½ bushels, and shavings for lighting it. It should be allowed twenty minutes to light properly. The grate should be well cleared out before lightiug.

To heat the Shot.

Fifteen 32-pounder shot being then put in are heated in from 40 to 50 minutes.

Order of using the Shot.

The shot should be taken equally out of each row from the rear of the furnace, and replaced by cold ones from the front. If those which present themselves are not sufficiently hot, they must be returned at the front.

After the furnace has been thoroughly heated, it will supply a new batch of shot every thirty or forty minutes, depending on the draught and fuel.

The furnace should be placed to leeward, and as near the battery as may be convenient, carefully selecting an open space, with as great a draught as can be found. The draught-hole should be to windward, and the furnace perfectly horizontal. Earth ought to be thrown up against the furnace so as to close all the sides except that to windward.

THE IMPROVED SHOT FURNACE.

This furnace weighs about 30 cwt., and will contain 36 68-pr. shot.

It is composed of four parts:—

1. The ash-box, made of $\frac{5}{16}''$ boiler plate.
2. The furnace of ⅜ boiler plate (with an air channel round it), and lined with fire brick.
3. The furnace hood, containing the sloping bars, entrances, and doors for the shot.
4. The detached fan with wheel and pinion, worked by two handles.
5. The height of the *entire* furnace is 4 ft. 8 in. from the ground; *there is no chimney.*

The shot furnace of the service is in future to be fitted with a fan.

ARTICLE V.—MOLTEN IRON.

Shells of a peculiar construction, loaded with fluid iron, are used against objects which it is wished to set on fire.

The metal is poured in until it shows itself above the filling hole; it then receives a few blows with a hammer to flatten it, so as to present no obstruction to the rolling of the shell, if necessary. The shell is then turned with the filling hole downwards, and a wood bottom riveted on. For two or three minutes after filling, the shell may be readily handled, provided the man is supplied with a pair of founder's gloves, pieces of sand-bag, &c. After that time it gradually heats until it becomes dark red, when a shot-bearer is requisite to lift it into the gun.

On striking the object the shell either acts as an ordinary hot shot, or it breaks up, and scatters the iron.

The former result happens when about ten minutes or a quarter of an hour elapse between filling and firing, the latter when there is an interval of from one to five or six minutes only. The degree of fluidity of the metal, and its dispersion on striking, depend on the time it is allowed to remain in the shell.

The metal is run down in a cupola, by means of a fan blast worked by hand; the cupola is mounted on framing, supported on two 3′ 9″ wheels in front, and on two legs behind. Two ladders enable men to get on the top of the stage (forming a case for the fan) and charge the furnace.

With the cupola are furnished two ladles, two hangers, two tapping bars, two rakes, two clearing hoops, one clearing plate, one tapping hammer, and two small filling funnels.

The iron used should be, if possible, in small masses, such as old shot or shell.

ARTICLE VII.—NAVAL SLIDES.

For the 68-pounder. „ 10-inch guns.	Four additional men are required, numbered 11, 12, 13, 14.
„ 8-inch of 65 cwt.	Two additional men, numbered 11, 12.

These men are necessary in traversing; Nos. 11 and 12 coil up falls.

Four sets of luff-tackle are required, brought up, when preparing for action, by Nos. 2, 3, 4, 5;—Nos. 2 and 3 hook the moveable blocks of the running-up tackles to the eye-bolts, outside the cheek in front;—Nos. 4 and 5 to the eyes on the levers at the rear chocks;—Nos. 4 and 5 hook the moveable blocks of the traversing tackles to the eye-bolts at the rear of the slide;—Nos. 11 and 12 hook the standing blocks to the eye-bolts or bollards at the sides.

The loading is as before detailed.

Running-up when the Compressors are not used.

Nos. 2, 3, 4, 5, 6, 7, 11, 12, 13, 14 man the running-up falls, and *haul taut.* At the word "*Heave,*" they give a hearty heave, and

allow the carriage to run down the slide; No. 1 gives the word "*Halt*," just before the carriage is *up*, when the numbers on the fall let go.

When the compressors are used, the running up is by jerks. Nos. 4 and 5 tighten them when the gun is up.

No. 7 primes directly the elevation is obtained.

Traversing.

Nos. 2, 3, 4, and 5 with handspikes as before; 11, 12, 13, 14 man the traversing falls on their own sides, and haul taut, waiting for directions from No. 1, who, having got his elevation in the usual manner, stands in rear of the slide, looking over the gun. At "*Trail right*," the even numbers haul, the odd numbers ease off. At "*Trail left*," the odd haul and the even ease off, the handspike man heaving: No. 1 gives the word "*Fire*," when he covers his object.

In running the gun back at drill, No. 1 engages a truck lever in the eye-bolt in rear of the chock. Nos. 4 and 5 unhook the moveable traversing blocks, overhaul the running-up tackles, and hook them into the rear eye-bolts in the slide;—all the numbers but 1 man the fall; he bears down on the lever. "*Heave away.*" "*Halt*," Nos. 4 and 5 unhook blocks, and hook them to levers on rear chock.

Article VIII.—Guns, or Carronades on Depressing Carriages.

When, after being fired, the piece is to be loaded, it must be brought to such a position that the sponge may be clear of the ground, or sill of the embrasure. Short pieces are best suited for firing at great depression, as they are easily managed and quickly loaded.

Article IX.—Exercise of Ten, and Eight-inch Howitzers.

The loading, pointing, and firing is as before described, except that No. 2, after sponging, reverses the sponge, as with field guns, and rams home. Should reduced charges be used, as in ricochet firing, they must be either lengthened with wads, or rammed home separately, and the same rule applies with all shell guns.

Article X.—Exercise of Mortars on Standing Beds, and Ground Platforms.

The detachment files on to the mortar from the rear, as with guns firing over a low parapet. 2 and 3 halt in line with the muzzle; 4 and 5 the trunnions; 6 and 7 the rear of the bed. The front numbers two feet from the mortar bed, the remaining numbers uncovering outwards.

13, and 10-inch mortars.
1 N. C. officer and 9 men.
1, points, and commands.

3, plants pointing rods; puts in cartridge; assists to put in shell; runs up, traverses.

2, sponges; assists to put in shell; runs up, traverses.

5, runs up, traverses.

4, serves the vent; runs up, and traverses.

7, supplies 3 with cartridges; assists at his handspike, and fires.

6, hands the sponge to 2; assists at his handspike; wipes shell.

9, assists to prepare and bring up shells, and puts them in.

8, supplies cartridges from the magazine; assists to prepare and bring up shells, and puts them in.

10, at the magazine.

With 8-inch mortars, 7 men only are required.

No. 1 points; commands; hands sponge to No. 2.

3, runs up, traverses, provides cartridges, and puts them in; plants pointing rods.

2, sponges; traverses; runs up; wipes shell.

5, assists 6 to prepare shells; fires; runs up; and traverses.

4, serves the vent; runs up, and traverses.

6, prepares shells; brings them up; and puts them in.

7, at the magazine.

With the smaller mortars, 5½ and 4⅗-inch, 3 men are sufficient.

The shells ought always to be deposited behind traverses raised for the purpose, or in other sheltered places, and one or two men, according to circumstances, should be appointed to scrape and clean them inside and out, and prepare them for the powder and fuzes.

Fuze for 13, 10, *and* 8-*inch Mortar Shells.*

The fuze for mortar shells has a spiral row of holes, the centres of which are ·2 of an inch apart in the direction of the axis of the fuze.

Directions for preparing the fuze for any particular range.

Hold the fuze firmly in the left hand, insert the point of the bit into the required hole, place the head of the brace against the body, and turn with the right hand until the stop comes in contact with the wood.

N.B.—The wood bottom of the fuze must on no account be cut off, as it supports the composition, and prevents its being disarranged by the shock at the discharge.

NOTE.—The 13, and 10-inch shells at present in store have larger fuze holes than those which will be hereafter cast. Fuzes on a similar *principle*, but larger in diameter, will be supplied with these shells.

The fuze holes of the old shells being irregular in size and shape, *the fuze must* be rasped if necessary.

The following stores are required for the service of mortars.

One sponge to be placed on the right of the mortar, the sponge head to the front, and supported to keep it free from gravel.

One scraper for two mortars.

One cartridge case, for bringing up the cartridge.

One beam hook, for 13-inch, *One pair of hand hooks,* for 10-inch.

One piece of cord, for 8-inch.

Four handspikes, for 13, 10, and 8-inch. Two on each side of the platform, as directed for guns.

Two pointing rods, or pickets. If for masonry parapet, set on a 2-inch plank, 4' long.

One plummet with silk line, in charge of No. 1.

A piece of sheepskin, or an empty sand bag for wiping the bottom of the shell; to be placed on the right of the sponge.

One quadrant,
One perpendicular,
One fuze engine,
} for every four or five mortars.

One tube pocket, and friction tubes.

One lanyard with hook, for friction tubes.

One set of priming irons.

One filling funnel.

One set of fuze implements, No. 7, for every two mortars, and 25 per cent. spare.

The set consists of,—Brace, 1; cylinders containing 6 bits, 2; Instructions, printed, 5; mallet, 1; sections of fuze, 5; setter, 1; wrench for removing fuze-hole plug, 1.

Chalk prepared, and piece of fine cord for striking a line.

Shells, of the calibre of the mortar, and also 4⅖ inch for volleys in boxes.

Pound shot, in boxes. Bottoms for ditto.

Lanthorn. Fuzes, Mortar.

1 *wrench hammer. Carcasses.*

Light-balls. { Ground. Parachute.

Spare quoins for 15°, 75°.

At the Magazine.

One set of weights and scales.

One set of powder measures.

Cartridges empty, worsted 1lb.; Scissors; Needles.

Mortars are prepared for action on the same principle that guns are.

No. 1 commands, and regulates the charge of powder and length of fuze.

Laying Mortars.

Mortars are usually fired from behind parapets, the height of which prevents those *in the interior* of the battery from seeing the object *fired at, unless they expose* themselves. The mortar is therefore laid,

not directly at the object, but upon two pickets, called *pointing rods*, which are placed in front of each mortar, and in the vertical plane, passing between the centre of the platform and the object to be struck.

Carcasses, and Light Balls.

When carcasses, or light balls are fired, the 13, and 10-inch are brought up in the same manner as shells; the 8, 5½, and 4⅖-inch in the palms of the hands. No. 2 wipes the bottom of the carcass, uncovers the holes, and loosens the priming.

Light balls, both ground and parachute, are fired with very reduced charges.

Pound Shot, and Stones.

When pound shot, or stones are used, they are brought up in a box, or basket, to the front of the mortar in the same manner as shells. The number who brings up the cartridge, brings up a wooden bottom which 3 places over the powder. Nos. 2 and 3 empty the shot into the mortar, and give the empty basket to 6.

Directly the mortar is loaded, the word "*ready*" is given, and 2 and 3 take two oblique paces outwards to the rear, so as to be clear of the explosion.

ARTICLE XII.—FIRING BY NIGHT.

To insure as accurate a fire as possible during the night, the following expedients have been adopted:—

The gun having been properly laid during the day, a bead or piece of timber of a proper scantling is nailed or screwed to the platform, inside the felloe of each wheel, and parallel to the object line, and two shorter pieces are fastened in like manner outside of the cheeks of the carriage at the trail.

By a proper application of the scotches, traversing platforms can be made available for night firing.

Or the platform and the carriage should be chalked, and when the gun is run up, these chalk marks should be made to correspond. A lantern, in this case, is always required.

The elevating screw must also be clamped, or the quoins lashed.

For Mortars.

After the mortar has been accurately laid, a plank, thin enough to go under the running-up bolts without touching them, is placed against the outside of one of the cheeks of the bed, and nailed or screwed to the platform, and the mortar, after every round, run up to it. If a suitable piece of plank cannot be procured, the platform must be chalked close to the mortar bed.

ARTICLE XIII.—FIRING AT MOVING OBJECTS.

Supposing the vessel to be 250 feet long, and a knot to be 2,028 yards, she will run her own length in 12·3″; it will, therefore, be necessary at 1,000 yards to aim about 20 yards in front of the spot it is intended that the shot should strike.

With a 32-pr. 56 cwt. 10 lb. charge, it will be necessary to aim at the vessel's bows if it is desired to hit her centre, when at a distance requiring 4° elevation; and rather ahead of her at 6°.

PART III.—ARTICLE I.—SLEDGES

Are constructed of beams 10 inches in depth, 6 inches in thickness, and 10 feet 3 inches in length, parallel to each other, and at the distance of 1 foot 5 inches apart, and connected by wooden transoms. They are easily put together, and have been found of great service in small expeditions, in which recourse has been had to the Navy for ships' guns to carry on operations on shore.

If the ground be of a marshy or shingly nature, the under part of the sledge must be covered with planks to prevent mud, stones, &c., from accumulating in front of the transoms; and, if there be time, the under part of the side pièces should be shod with iron, to prevent them wearing away.

There is a narrow description of sledge, which is made use of to move guns along sally ports and similar narrow passages, and up the ramps of fortifications. Guiding ropes are made fast to the rear of the sledge, and manned towards the rear, crossing each other, so that the men haul upon that which is fixed to the side farthest from them.

ARTICLE III.—SLING CART.

This cart is used for moving heavy guns, not exceeding 65 cwt., on *hard, level* roads, and for 8-inch, and 10-inch mortars.

The cart weighs 15 cwt.

One non-commissioned officer and six men are required to work it. They are numbered as for gun drill.

Articles required with the cart:—

One sling, of six-inch white rope, two fathoms long, with an eye splice at each end.

One sling tie.

One-inch tarred rope, two feet long.

One prypole, fitted with a prypole rope, 2½ inch, three fathoms.

Two levers, six feet nine inches long, fitted with two lever ropes, two-inch tarred, two fathoms long.

Two pawls.

Two common handspikes.

One piece of short skidding, 4½ feet long, five or six inches square.

The same windlass is applicable to either sling waggon, or sling cart.

The detachment halts about three yards (the position of detachment

rear) in rear of, and facing the cart, which is supposed to be provided with its stores, viz., the sling on the windlass, the handspikes and levers lashed to the prypole. The gun to be slung is on a short skid. No. 1 gives the word "Form the order of exercise," "*right face—left wheel—quick march.*" The ranks open out; the front rank covering the left wheel; the rear rank the right. They are halted at one pace from them.

General Detail of Duties.

No. 1 attends to the pawls and commands.

Left side.

3 has charge of the left lever, and skids the gun, when necessary.

5 has charge of a handspike, assists 3 at the lever and skidding, and raises the weight when it is to be lashed.

7 assists 3 at the lever, slings, and unslings the gun, and lashes it to the prypole.

Right side.

2 has charge of the right lever, and skids the gun when necessary.

4 has charge of a handspike, assists 2 at the lever and skidding, and raises the weight when it is to be lashed.

6 assists 2 at the lever, slings, and unslings the gun, and lashes it to the prypole.

If the cart is not horsed, and requires moving a short distance, 6 and 7 hold up the shafts, the remaining numbers man the wheels, the even numbers being on the right, the odd numbers on the left.

Words of command.

UNLASH.
SLEW THE GUN, RAISE THE TRUNNION ON THE RIGHT.
HALT, CAST OFF. BACK THE CART.
FIX SLING TO RIGHT OF WINDLASS.
OVERHAUL, AND SLING GUN.
HEAVE IN THE SLACK.
WORK LEVERS.
HALT, OUT LEVERS.
LASH UP THE BREECH.
HEAVE. FRAP, AND MAKE FAST.
LASH LEVERS AND HANDSPIKES.

Unslinging.

In unslinging each number undoes what he has previously done.

Words of command.

PREPARE TO UNSLING.
LEVERS TAKE PURCHASE TO LOWER.
BEAR DOWN.
EASE OFF.
UNSLING.

The trunnions are slewed as before.

In slinging, should the gun not be on skids, it may be necessary to place a handspike in the bore, move the cart until the windlass is over the handspike, fix the sling, work the windlass until the gun is raised, and then place a skid or two handspikes under the gun, so as to give room for passing the sling underneath.

Slinging 8-inch, and 10-inch Mortars.

A mortar is slung with the muzzle towards the rear. It is slewed like a gun.

The sling is then put on close to the trunnions.

Unslinging a Mortar.

See unslinging a gun.

Slinging a Mortar Bed.

The windlass for raising mortar beds is generally of a different construction from that of guns, being square in the middle, and cylindrical at each end. Both ends of the sling are put on the pins placed for that purpose on the square part of the windlass, which in this case bears the whole weight. If the ordinary windlass is used, one side of the bed must be first raised.

The bed is slung with the front part towards the rear of the cart.

If the bed be not on skids, the hind part must be raised eight or nine inches off the ground, and there propped with the quoin, to allow of the sling being passed under.

Unslinging a 13-inch Mortar Bed,

Is just the reverse of slinging, each number undoing what he had previously done.

ARTICLE V.—SLING WAGGON.

The sling waggon weighs about 29 cwt., and is employed for moving heavy ordnance, standing carriages, and traversing platforms. It requires a detachment of one non-commissioned officer and eight men.

The following articles are required with the waggon:

One sling of six-inch white rope, 2½ fathoms long, and having an eye splice at each end.

One sling tie of one-inch tarred rope, two feet long.

One breech rope, or *carriage sling*, of 2½-inch tarred rope, six fathoms long.

Two levers, six feet nine inches long, fitted with

Two lever ropes, of two-inch tarred rope, 2½ fathoms each.

Two pawls, wood.

Four common handspikes.

Two pieces of skidding, about four feet long, and six or seven inches square.

One pair of strong dragropes.

One wrench hammer.

The detachment is numbered in the usual manner, and takes post for exercise as at the sling cart.

General Detail of Duties.

No. 1 attends to the pawls, keys, and unkeys keep chain, and commands.

Left side.

3 has charge of the left lever, and skidding, scotches the wheels in rear.

5 has charge of a handspike, assists 3 at the lever, scotches the wheels in front, fixes the carriage sling, if necessary.

7 assists 3 at the lever, slings, and unslings the gun, lashes the breech, handspikes, and levers.

9 assists in keying, and unkeying the draught chain, and fixing the breech rope; assists to lash the breech.

Right side.

2 has charge of the right lever, and skidding, scotches the wheels in rear.

4 has charge of a handspike, assists 2 at the lever, scotches the wheels in front, fixes the carriage sling, if necessary.

6 assists 2 at the lever, slings, and unslings the gun, lashes the breech, handspikes, and levers.

8 keys, and unkeys the draught chain and fixes the breech rope, and assists to lash the breech.

The whole assist to limber up, and unlimber.

To sling the Gun, and mount the Carriage.

Position of the gun, and carriage.—The gun is on skids, and its carriage on one side, with its breast nearly in line with the breech.

The gun is slewed as before, and the waggon is run over it (the even numbers on the right side, and the odd on the left) until the axletree is over the trunnions, and the perch over the breech. The handspikes, levers, and sling, as at the sling cart exercise. The windlass is supposed to be pawled with the wooden pawls.

Words of command.

PREPARE TO UNLIMBER.
UNLIMBER. LOWER.
RUN THE WAGGON BACK.
PREPARE TO TURN THE GUN CARRIAGE OVER.
HEAVE.
OFF TRUCKS.
LIFT THE REAR OF THE CARRIAGE AND PLACE THE LEVER.
MOUNT THE CARRIAGE. HEAVE.
WORK LEVERS.
HIGH ENOUGH, OUT LEVERS, OFF SLING.
RAISE THE REAR OF THE CARRIAGE, OUT LEVER.
PREPARE TO LIMBER UP. LIMBER UP.
BACK THE WAGGON.
SCOTCH HIND WHEELS.
PUT ON TRUCKS.
SLING THE GUN, WORK LEVERS, ETC.
PREPARE TO RAISE THE BREECH.
RAISE THE BREECH. FRAP, AND MAKE FAST.
PLACE STOOLBED* AND QUOIN.
LASH UP LEVERS AND HANDSPIKES.

* With standing carriages.

Dismounting the Gun, and Carriage.

PLACE SKIDS, UNLASH, AND SCOTCH THE WHEELS.
UNLASH THE BREECH.
LEVERS TAKE PURCHASE TO LOWER.
BEAR DOWN. EASE OFF. UNSLING.
PREPARE TO UNLIMBER. UNLIMBER. DISMOUNT CARRIAGE.
TURN THE CARRIAGE OVER. LIMBER UP.

Slinging Howitzers.

A howitzer is slung in the same manner as a gun.

Slinging Mortars.

A 13-inch mortar, and its bed, require each a waggon; but a 10, or an 8-inch mortar can be conveyed on its bed by one waggon.

A 13-inch mortar, lying on skids, is slewed like a gun, the sling being passed round close to both trunnions, and a piece of short skidding put into the muzzle, by which to lash it to the perch. The muzzle is raised, and secured in the same manner as the breech of a gun.

Slinging a 13-inch Mortar Bed.

The mortar bed is traversed, and the waggon backed over it, in such a manner that the front of the bed may be next the shafts. The front of the bed is raised, and the bed slung as at the sling cart; 6 and 7 passing the ends of their ropes round the running-up bolts and over the perch, where they are double manned by 8 and 9; 2, 3, 4, 5 heaving up with handspikes. The bed is then raised till the under side is horizontal; after which a second turn is taken round the running-up bolts. The whole is then frapped, and made fast with a reef knot.

Slinging a 10, or 8-inch Mortar, and Bed.

Ten, or 8-inch mortars are not dismounted for slinging. Their quoins are taken out, and the mortar is laid on the front transom, with its muzzle to the front. All the other parts of the operation are the same as detailed in the preceding paragraph, except that the sling, in order that it may be under the centre of gravity of the load, must be passed under the bed, about two inches in *front* of the centre of the trunnions.

Slinging a Traversing Platform.

The platform must be on skids, bottom upwards. The sling is passed round it so as to leave the centre of gravity just under the axletree.

ARTICLE VII.—TRIANGLE GYNS.

There are two patterns, the 18 feet, and the 16 feet. The former are for general service; the latter are applicable only to mounting guns on travelling, or standing carriages, platform waggons, &c., and two of them are required with all guns heavier than 56 cwt.

The rear of the gyn is the part where the windlass is fixed. The front of the gyn is the prypole.

One non-commissioned officer and 12 men can raise, work, and carry either pattern very short distances, but generally they should be placed in a hand cart.

The detachment is halted in line facing the rear of the gyn, or the windlass. TAKE POST ON THE GYN, RIGHT-FACE, LEFT WHEEL, QUICK-MARCH. The ranks open out, the front rank covering the left cheek; the rear rank, the right. They are halted at one pace from the cheeks.

Stores required for the Service of the Gyns.

One fall, 3½-inch white rope, 96 feet long; but only 72 feet for the small gyn.

The windlass is similar to that already described for the sling waggon, and sling cart.

With both patterns.

Three handspikes.

Two levers and lever ropes.

One triple block.

One double block, or 2 *triple blocks*, with 68-pr. and 10″ guns.

One sling, of 6-inch white rope, of a length to suit the dimension of the gun, or other object which is to be slung.

One single lashing rope, 2½-inch, for slinging mortars.

One piece of spunyarn, three-stranded, 1½ fathom long, for seizing the clinch of the fall.

One piece of spunyarn, one fathom long, for seizing the stopper.

One fid, for slinging the gun; or,—

One short piece of skidding, for the same purpose, for slinging mortars, and howitzers.

One hammer, and one wrench hammer.

Three trucks, or *small pieces of board*, four inches thick, with a hole in the centre of each, to receive the spikes of the feet of the gyn on soft ground. Handspikes laid upon the ground, and on each side of the spikes, will answer this purpose.

One pair of dragropes.

One spade, and pick.

The gyn should be placed, if possible, on level ground.

General Duties of the Men.

No 1 commands.

Left Side.

3 has charge of the left lever, keys, and unkeys the left capsquare, runs the carriage up, or back.

5 assists 3 at the lever, runs the carriage up, or back.

Right Side.

2 has charge of the right lever, keys, and unkeys the right capsquare, runs the carriage up, or back.

4 assists 2 at the lever, runs the carriage up, or back.

7 assists 6 to pass the fall round the windlass, holds on next to him.

6 passes the fall round windlass, holds on the fall and makes it fast, eases off the fall, and lowers the gun.

9 holds on the fall behind 7, and coils it up.

8 holds on the fall behind 6.

11 reeves, and unreeves the triple block, if necessary, assists in slinging the gun, and steadies it on his own side.

10 reeves, and unreeves the double block, if necessary, assists in slinging the gun, and steadies it on his own side.

13 assists to work levers.

12 assists to work levers.

The whole of the numbers assist to carry the gyn and put it together.

*PUT THE GYN TOGETHER.

PLACE THE WINDLASS.

The tackle is brought close to the gyn; the running end of the fall coiled on the left.

2. *Raising the Gyn.*

*PREPARE TO RAISE THE GYN.

HOOK THE TACKLE.

RAISE THE GYN.

HALT.

3. *Placing the Gyn.*

*PREPARE TO PLACE THE GYN.

LIFT THE CHEEKS IN, OUT, TO THE RIGHT, OR TO THE LEFT.

ARTICLE VIII.—GIBRALTAR GYN.

The Gibraltar gyn may be used for mounting and dismounting ordnance on and from standing carriages in situations where a triangle gyn could not be conveniently used. It weighs 10¾ cwt., and can support 3 tons with safety.

The following stores are required for the service of the gyn:—

One fall, of 3½-inch white rope, eight fathoms long.

Two lashings for slinging the gun, of 2½-inch tarred rope, each twenty feet long.

One stopper, about 5½ feet long, of 2½-inch tarred rope, more than one-half plaited as a gasket.

One iron triple block, with brass sheaves, to which is attached a bar of iron 2½ feet long for suspending the gun, its ends turned up to prevent the slings slipping off.

Four handspikes.

Two dragropes.

One non-commissioned officer and six men are allowed for working the gyn.

The gyn is moved by means of dragropes hooked to the staples of

* *Words of command*, CAPITALS.

the front or rear axletrees by Nos. 6 and 7. It can be drawn short distances over hard level ground by the working detachment of six men.

The rear of the gyn is the part where the windlass is fixed.

The detachment is formed a few paces in rear of the gyn. "TAKE POST FOR EXERCISE—TO THE RIGHT FACE—QUICK MARCH."—The detachment wheels to the left, and the ranks open out. Nos. 2 and 3 halt one pace in rear of their respective axletree arms. The whole one pace from each other and covering.

General Duties of the Detachment.

No. 1 commands.

Left Side.

3 runs the carriage up, or back, heaves round the windlass, assists 7 to sling the gun.

5 runs the carriage up, or back, assists to hold on the fall, stoppers, and unstoppers it.

7 reeves the tackle, slings, and unslings the gun at the chase, and steadies it.

Right Side.

2 runs the carriage up, or back, heaves round the windlass, assists 6 to sling the gun.

4 runs the carriage up, or back, holds on the fall, makes it fast, and lowers the gun.

6 reeves the tackle, if necessary, slings, and unslings the gun near the first reinforce, steadies the gun, and overhauls the tackle.

Words of Command.

PREPARE TO PLACE THE GYN.
PLACE THE GYN.
REEVE THE TACKLE.
PREPARE TO SLING THE PIECE.
SLING THE PIECE.
HAUL IN THE SLACK.
HEAVE ROUND THE WINDLASS.
HALT, STOPPER THE FALL.
SHIFT THE FALL.
HALT.

The carriage having been run under the piece, or away from it, as may be required, the piece is lowered and cast loose, each number reversing the operations which he performed in lashing and raising it.

PART VI.—ARTICLE IV.—SHEERS.

The legs or spars for sheers ought to be from 30 to 40 feet in length, and from five to ten or twelve inches in diameter at their butt end, both of these dimensions depending on the nature of the operation to be performed; the longer the spars are, the greater will be the heel obtained.

Sheers erected on the sea beach must always be of a large size, and *placed so far in* the water that a boat with a heavy gun in it can float *under them.*

Small sheers in such cases can only be used when the water is smooth.

According to the nature of the operation, sheers when raised may be perpendicular, or they may be made to incline forward, or backward.

Should they be employed to raise guns on the ramparts of a fortification, they must, if possible, have such an inclination forwards as that, when the gun is being raised, it may not rub against the escarp.

The greater the inclination of the sheers, the greater will be the strain on the guy which supports the top, and a preventer guy as a precautionary measure may be sometimes advisable.

By removing its prypole, the gyn can be used as sheers; but in this case a piece of wood, about five or six inches long, similar in every respect to the top of the prypole, must be placed in the collar or shackle, and the bolt passed through it and the cheeks.

Article VI.—To Land Heavy Guns dismounted, from Boats or Rafts by Parbuckling; and also to embark them.

In the embarkation, or disembarkation of heavy guns dismounted, in or from boats or rafts by means of skids, the greatest attention must be paid, that the ends of the skids do not rest on the gunwale, but at a proper distance within the boat; by which means the bearing will be thrown so much inwards, that, when the weight of the gun acts on the boat, the latter will not heel too much, and thus the gunwale will not be forced under water, or the boat greatly strained.

In embarking a gun, the boat must be kept at such a distance from the shore, that it do not touch the ground when the gun is on board, or that it just barely touch the ground. In disembarking, the boat ought to be brought as close to the shore as possible.

The above observations only apply to smooth water.

Where there is a swell, parbuckling is not to be attempted, and recourse must be had to shears.

The gun may be parbuckled, or embarked:

1st. *From a place considerably higher than a boat or raft.*

2nd. *From a place on the same level; these two are the most advantageous cases, for the gun descends one inclined plane only; or,*

3rd. *From a place which is lower, as the sea beach.*

In the first case, the skids may be made to bear on the bottom of the boat, and the gun placed there by removing one or two of the thwarts; dunnage, however, will be required, consisting of some three-inch or other planks placed fore and aft, on which two pieces of short skidding are to be laid for the gun to rest on; the ends of the parbuckling skids should rest on the dunnage, and immediately over a rib.

A raft has the advantage over a boat, in that its upper surface is quite flush, whereas the gunwale of the boat is higher than the part of it on which the gun *is to rest*, and consequently, as in the 3rd case, the *gun has first to mount on the* skids on one side, and descend on the *skids on the other side*, and two sets of parbuckles are required; indeed,

they are necessary when there is a current or a gentle surf, which may cause the boat to rise, and fall.

In embarking, the boat parbuckles are for parbuckling the gun up the embarking skids, and the shore ones for checking it, or easing it from the skids to its place on the thwarts.

In disembarking, the shore parbuckles are for parbuckling the gun from the boat to the disembarking skids; the gun is checked by the boat parbuckles.

The boat ends of the embarking skids must be higher than, and not touch the gunwale; they are to be placed directly over the thwarts, and to rest on planks or pieces of timber laid over the thwarts; or, when local circumstances admit of it, on the thwarts themselves, to which they ought to be lashed, and which must be propped in the middle, as the gun is in general to rest on them.

The boat must be kept steady and close to the shore by four ropes at the head and stern, secured to posts or anchors.

The carriage is embarked after the gun, being made to slide along the skids. If a standing carriage, the skids must be brought closer together. If a travelling one, it may be pushed along side foremost; or, if breast foremost, each axletree-arm must rest on a skid, and a short plank or lever lashed across the cheeks of the trail, the ends resting on the skids.

The following implements will in general be required:

Eight handspikes.

Two skids (bevelled at the ends), about 14 or 16 feet long, and sometimes more, according to circumstances; they ought to have eye-bolts, or holes bored near their ends for the reception of bolts, so that a rope could be passed round them, and secured to the thwarts.

Four short skids.

Three or four planks, or pieces of wood, as the case may require, to lay on the thwarts, on which the boat ends of the skids are to rest, and thus keep them clear of the gunwale.

Four quoins or wedges, to facilitate the ascent and descent of the gun on and from the skids.

Five or six scotches.

Four parbuckles, each twelve fathoms long.

Two or more luff tackles, according to circumstances.

Four posts. *Four selvagees.*

One maul.

Two pieces of two-and-a-half inch rope, each six fathoms, for head and stern ropes.

Two skid lashings, two-and-a-half-inch rope, each three fathoms.

Two iron bolts, about eighteen or twenty inches long, for the skids.

Two small anchors, or *one anchor and a grapnel.*

Two cables, three-inch rope, each ten fathoms; and according to local circumstances, a greater or less number of these articles may be required.

The number of men required for the operation must vary according to circumstances; but, two non-commissioned officers and fourteen men will be required to arrange everything, and in some instances may

embark and disembark the gun; there must, however, be a sufficient number for pulling and hauling; the men are divided into two parties, or one non-commissioned officer and eight men for the shore duties, and one non-commissioned officer and six men for the duties in the boat or raft.

ARTICLE VII.—TO LAND, AND EMBARK FIELD GUNS MOUNTED, FROM, AND IN BOATS.

This is a most essential operation, and the field artillery attached to the division of troops which is first to land, or last to embark, should always be landed in the mode hereafter stated.

Any boat, if large enough, can be fitted for this purpose; paddle-box boats answer extremely well.

The limber must always accompany the gun, by which means the latter travels with greater facility, and the ammunition is more easily and conveniently carried.

Arrangements should be made so as to allow of the gun being fired when in the boat; a handspike being lashed under and across the trail. If necessary, the limber may be taken to pieces and stowed away in the boat, care being taken that the different parts of it bear on the flooring, and that they do not touch the planking.

The boats are fitted by means of two planks, laid from the bow to the stern, parallel to and at a distance from each other corresponding to the span of the wheels; each is furnished with a longitudinal batten, to prevent the wheel from slipping off.

The following implements are required for this operation:

Two embarking skids or railway planks, twelve or fourteen feet long.

Two short railway planks, to keep up the communication between the embarking skids and the railway planks in the boat.

One bow beam or broad piece of timber for laying across on the gunwale of the boat, a little within the bow to support the ends of the embarking skids.

Eight lashings of two-inch rope with eyesplices; four of which are three fathoms long for securing the short rails to the bow beam, and the other four, one-and-a-half fathoms long, for securing the long rails to the belaying cleats on the bow beam.

PART V.

FIELD ARTILLERY EXERCISES.

*PART III.—PARADE, AND INSPECTION.

TELLING OFF, AND PROVING.

*6. The battery, limbered up, is told off by sub-divisions, divisions, and half-batteries.

One gun and its waggon constitute a sub-division,
Two sub-divisions „ „ a division.
Three sub-divisions „ „ a half-battery.

It is numbered from right to left by sub-divisions. It is then told off into 3 divisions. No. 1 the right; No. 2 the centre; No. 3 the left. Sub-divisions Nos. 1, 3, and 5 are also distinguished as right sub-divisions of divisions, and Nos. 2, 4, and 6, left; the two centre sub-divisions are also to be named. It is also told off into half-batteries, and these are distinguished by right, centre, and left sub-divisions of half-batteries. The gun of direction should always be named, generally the right centre gun.

7. The battery is then proved by naming a sub-division, division, half-battery, or any individual number of the gun detachment. At the word *Prove* every man of the named sub-division raises the right arm as high as the shoulder, and extends it to the front, keeping it up until another part is ordered to prove.

8. *Spare Carriages*, when with the battery, form a third, and if necessary a fourth line in the rear, carriages covering their own sub-divisions.

S. 2. Posts, and Duties of Officers at Exercise.

First Captain.

In line, limbered up.—Half a horse's length in front of the centre of the battery.

In column of batteries.—One horse's length in front and three on pivot flank.

In column of sub-divisions, divisions, or half-batteries.—Three horses' lengths on pivot flank of centre of battery.

Second Captain.

In line, limbered up.—One horse's length in rear of the centre.

In open column of batteries.—As in line.

* *Note.*—In consequence of the limited size of 'THE ARTILLERIST'S MANUAL, &c.,' only *brief* extracts have been taken from 'MANUAL OF FIELD ARTILLERY EXERCISES, 1861.'

In close column of batteries.—One horse's length on reverse flank in line with the leaders.

In column of sub-divisions, divisions, or half-batteries.—Two horses' lengths from the centre on the reverse flank.

In column of route.—In rear of carriages.

In action.—He assists the captain in general superintendence.

He dresses all points of formation, gives the word *Steady* when they have been correctly taken up and the formation complete; when required he commands a division.

Subalterns.

In line, limbered up.—Between their sub-divisions in line with the leaders of the guns.

In column of sub-divisions or route.—One horse's length on the pivot flanks of the centre of their divisions.

In column of divisions.—Between their sub-divisions in line with the leaders of the guns.

In column of half-batteries.—The subaltern of the centre division, if right in front, between 2 and 3 sub-divisions; if left in front, between 4 and 5 sub-divisions. The others continue as when in line.

In close, or quarter intervals.—Half a horse's length in front of centre of their divisions.

In action.—Between the guns of their divisions, a little in rear.

In shifting from one position to the other.—It is always by the shortest way, and in a canter.

Adjutant.

In line, limbered up.—In centre of the brigade, in line with the leaders of the guns.

In column.—On reverse flank of leading battery.

PART IV.—PRELIMINARY OBSERVATIONS.

S. 1. *Manœuvres.*

1. Artillery, without being obliged to follow step by step the manœuvres of cavalry or infantry, proceeds to the execution of the orders it receives in the easiest and most expeditious manner. It should, however, remain in rear of any intended alignment until the other troops are finally formed, unless ordered to the front to cover the formation.

2. It must be remembered that Artillery cannot be wheeled about on its own ground when acting with other troops; sufficient interval should be allowed on each flank to enable the sub-divisions to wheel outwards if required.

23. The following manœuvres are for a battery of 6 guns and 6 waggons, 6 horses *to each carriage.*

The movements from column are from a column right in front.

S. 2. *Brigade Movements.—Preliminary Observations.*

1. Batteries are formed in line, at an interval from each other equal to an interval and a half of a sub-division of a battery.

9. All formations of line from column, or column from line, are made at full intervals unless otherwise ordered, without reference to whether the brigade was at full, or close intervals.

27. The evolutions of several batteries acting together are on the same principles as those of one battery.

29. The movements from column have all been laid down as from a column right in front; if the column is left in front, they will be performed by the opposite words of command.

Extract from " Field Exercise and Evolutions of Infantry.

" POSITION OF ARTILLERY.

" *Position of the Battery of Artillery when moving with a Brigade.*

" The usual position of a battery of Artillery, when in line, is on the right, with an interval of 22½ yards, 28½ yards, or 34½ yards, according to the number of horses in the guns, whether four, six, or eight.

" When the battalions are in contiguous quarter-distance columns, the battery will be on a flank, as ordered, at a distance equal to the depth of the strongest column in rear of the alignment, unless they are formed for inspection or review, in which case they will be dressed with the leaders' heads on the alignment. In echellon the battery will be on a flank.

" When squares are formed in echellon, and the battery is brought into action, the muzzles of the guns should be in line with the rear base of the rear square.

" N.B.—A battery *on all occasions* to keep its full interval when possible.

" It is the duty of the Commander of the Artillery to keep his battery so well in hand that he may never interfere with deployments or other movements of the brigade; and the Brigadier should impress on the Officers commanding regiments, that they should at all times give way to the guns when the latter have occasion to advance or retire through a line, by smartly wheeling back a section or company.

" Should skirmishers be in front of the battery and be obliged to retire, they should only retire *to* the guns, and remain with them as long as they continue in action, retiring with them.

" Should the battery be detached from the brigade, two companies at least should accompany it as an escort.

" *These* remarks apply equally to Horse Artillery when working *with cavalry.*"

PART V.—SECTION 1. MANŒUVRES OF A BATTERY OF SIX PIECES.

Battery in Line.

No. 1.—TO ADVANCE.

* *Commanding Officer.* (Repeated by Officers.)	*Officers.*	*Nos.* 1.
The Battery will advance—March.	—	—

The pace is named by the commanding officer, and repeated by the officers before the word MARCH is given.

No. 2.—TO RETIRE.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Right (or Left) reverse—March.	—	

No. 3.—TO COME INTO ACTION.

Commanding Officer. (Repeated by Officers and Nos. 1).	*Officers.*	*Nos.* 1.
Action Front.	—	—

No. 4.—TO DIMINISH (OR INCREASE) INTERVALS ON THE MARCH.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
(*To diminish.*) Half, or Quarter, or close Intervals on—Sub-division. (*To increase.*) Full Intervals on—Sub-division.	—	Right (or Left) Incline—Trot—Forward—Walk (except No. 1 of the named Subdivision.)

The commanding officer names the sub-division on which the formation is to be made.

No. 5.—TO TAKE GROUND TO A FLANK.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Right (or Left) take Ground—March.	—	—

No. 6.—TO INCLINE ON THE MARCH.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Right (or Left) Incline.	—	—

To resume the original direction the word is "Forward."

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* *Commanding Officers'* words are always repeated by Officers.

No. 7.—TO FORM COLUMN OF SUB-DIVISIONS IN REAR OF A FLANK.

Commanding Officer.	*Officers.*	*Nos. 1.*
(Repeated by Officers.) —— Column of Sub-divisions in Rear of the Right—March.	Of Centre and Left Divisions—Right Reverse — Half Left.	Of 1—Waggon Right. Of 2—Right Reverse—Left Wheel—Left take Ground—Halt—Dress. Of 3, 4, 5, 6—Right Reverse—Half Left—Left—Left take Ground—Halt—Dress.

No. 8.—TO FORM COLUMN OF DIVISIONS IN REAR OF A FLANK.

Commanding Officer.	*Officers.*	*Nos. 1.*
(Repeated by Officers.) —— Column of Divisions in Rear of the Right—March.	Of Centre Division—Right Reverse—Eyes Left—Left take Ground—Left take Ground—Halt—Dress. Of Left Division—Right Reverse—Eyes Left—Left Incline—Left Incline—Left take Ground—Halt—Dress.	Of 3, 4, 5, and 6—Right Reverse.

The same principle applies to forming divisions in rear of the left, the markers to move out in that case being 1, 3, and 5.

Column of half batteries in rear of the right is formed in the same manner, the words of command for the left half battery will be the same as detailed above for the centre division.

No. 9.—TO FORM COLUMN OF SUB-DIVISIONS IN FRONT OF A FLANK.

Commanding Officer.	*Officers.*	*Nos. 1.*
(Repeated by Officers.) —— Column of Sub-divisions in Front of the Left—March.	Of Right and Centre Divisions — Forward — Half Left.	No. 6—Waggon right. Of 5—Forward—Left Wheel—Right take Ground—Halt—Dress. Of 1, 2, 3, 4—Forward—Half Left—Left—Right take Ground—Halt—Dress.

No. 10.—TO FORM COLUMN OF DIVISIONS IN FRONT OF A FLANK.

Commanding Officer.	*Officers.*	*Nos. 1.*
(Repeated by Officers.) —— Form Column of Divisions in Front of the *Left*—March.	Of Centre Division—Forward—Left take Ground—Waggons close Interval — Right take Ground — Halt—Dress. Of Right Division—Forward—Left Incline—Left Incline—Waggons close Interval—Right take Ground—Halt—Dress.	Of 1, 2, 3, and 4—Forward.

In forming column of half batteries in front of the left the words of command for the right half battery will be the same as above detailed for the centre division.

No. 11.—To Form Column of Divisions on the Centre Division.

This manœuvre is a combination of the Nos. 8 and 10.

No. 12.—To Change Front to the Rear by a Countermarch.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Change Front to Rear—Guns Right, —Waggons Left take Ground—March — Right Countermarch—Left, and Right take Ground—Halt—Dress.		

No. 13.—To Change Front to the Rear on the Centre.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Change Front to Rear on the Centre—March.	Of Centre Division — Sub-divisions Inwards about Wheel—Halt—Dress. Of Right Division—Forward—Left Wheel—Left Wheel—Halt—Dress. Of Left Division—Forward—Right Wheel—Right Wheel—Halt—Dress.	Of 1, 2, 5, and 6—Forward. Of 3 — Right Shoulders—Forward. Of 4—Left Shoulders—Forward.

No. 14.—To Change Front to the Rear when at Diminished Intervals (on the March).

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Change Front to the Rear on the Centre—Left Half Battery Halt—Half Batteries Inwards about Wheel—Forward.		

A battery at diminished intervals may also change front to the rear on the centre, and open out to full intervals in wheeling; the word of command is,—

CHANGE FRONT TO THE REAR ON THE CENTRE, FULL INTERVALS, ON NO. —*LEFT HALF* BATTERY HALT—HALF BATTERIES *INWARDS ABOUT WHEEL*—FORWARD.

No. 15.—To Change Front to a Flank, Right Back.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Change Front, Right Back —March.	Of Right and Centre Divisions —Left Reverse — Half Right.	Of 6—Left Wheel—Left about Wheel —Halt—Dress. Of 5—Left Reverse—Right Wheel—Right Reverse—Halt—Dress. Of 4, 3, 2, and 1—Left Reverse—Half Right—Right—Right Reverse—Halt —Dress.

No. 16.—To Change Front to a Flank, Left Back.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Change Front, Left—Back—March.	Of Centre and Left Divisions — Right Reverse—Half Left.	Of 1—Right Wheel—Right about Wheel—Halt—Dress. Of 2—Right Reverse—Left Wheel—Left Reverse—Halt—Dress. Of 3, 4, 5, and 6—Right Reverse—Half Left—Left—Left Reverse—Halt—Dress.

No. 17.—To Change Front to a Flank for Action.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Change Front, Right Back for Action—March (or) Change Front Left Back for Action—March.		

No. 18.—To Change Front to a Flank Right (or Left) Forward on a Flank Sub-division.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Change Front to the Left —March.	Of Right and Centre Divisions Forward—Subdivisions Half Left.	Of 6—Right Wheel—Right about Wheel—Halt—Dress. Of 4, 3, 2, and 1—Forward—Half Left—Left—Halt—Dress. Of 5—Forward—Left Wheel—Halt —Dress.

No. 19.—To Change Front on a Central Sub-Division.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Change Front to the Left on No. 4—March.	Of Right Division—Subdivisions Half Left—Of Left Division—Right Reverse.	Of 1 and 2—Half Left—Left—Halt—Dress. Of 3—Forward—Left Wheel—Halt—Dress. Of 4—Right Wheel—Right about Wheel—Halt—Dress. Of 5 and 6—Right Reverse—Left Wheel—Left Reverse—Halt—Dress.

A battery may change its front half right, or half left, on the same principle as already detailed. The commanding officer's words would be Change Front, Half Right, (or Half Left) on—Subdivision.

These manœuvres can be executed on the same principle, by divisions, or half batteries.

A battery can also change front on a moveable pivot by a simple wheel.

No. 20.—Change of Position to a Flank.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Change Position to the Right by the Oblique Echellon of Divisions—March—Form Line.	Half Right—Right—Halt—Dress.	

No. 21.—Change of Position by Throwing Back a Flank.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Change Position Right Back, by the Oblique Echellon of Divisions—March—Form Line.	Left Reverse—Half Right—Right—Right Reverse—Halt—Dress.	Of 1, 2, 3, 4, 5, and 6—Left Reverse.

Note.—Changes of position may be made half right in the same manner, the divisions forming oblique echellon by wheeling quarter right. To complete the wheel in forming line the word is Right. These movements may also be done by half batteries.

No. 22.—To Advance from a Flank in Column of Sub-divisions.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Advance from the Right in Column of Sub-divisions—*March.*	Of Centre and Left Divisions—Right take Ground.	Of 1—Forward—Waggon Right. Of 2, 3, 4, 5, and 6—Right take Ground—Left Wheel.

No. 23.—To Advance from a Flank in Column of Divisions.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Advance from the Right in Column of Divisions — March.	Of Right Division — Forward — Eyes Left. Of Centre and Left Divisions — Right take Ground — Left take Ground.	Of 1—Forward. Of 2—Forward—Waggon Right—Waggon Rear. Of 3, 5, and 6—Right take Ground. Of 4—Right take Ground—Waggon Right—Waggon Rear.

In advancing from the right in column of half batteries—the left half battery proceeds as detailed for the centre division.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Advance from the Left in Column of Divisions — March.	Of Left Division — Forward — Eyes Right. Of Centre and Right Divisions — Left take Ground — Right take Ground.	Of 6—Forward. Of 5—Forward—Waggon Left—Waggon Rear. Of 1, 2, and 4—Left take Ground. Of 3—Left take Ground—Waggon Left—Waggon Rear.

No. 24.—To Advance from the Centre in Double Column of Sub-Divisions.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Advance from the Centre in Double Column of Sub-divisions—March.	Of centre Division—Forward. Of Right Division—Left take Ground—March. Of Left Division—Right take Ground—March.	Of 3 and 4—Forward. Of 1 and 2—Left take Ground — Right take Ground. Of 5 and 6—Right take Ground — Left take Ground.

No. 25.—To Move from a Flank along the Front in Column of Sub-Divisions.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Advance from the Right *along the front in Column of Sub-divisions*—March.		Of 1—Forward—Waggon Right—Left wheel. Of 2, 3, 4, 5, and 6 in succession—Forward — March—Waggon Right—Left wheel.

No. 26.—To Move from a Flank along the Front in a Column of Divisions.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Advance from the Right along the front in Column of Divisions —March.	Of Right Division—Forward —Left wheel. Of Centre and Left Divisions —(in succession)—Forward —March—Left wheel.	Of 1, 2, 3, 4, 5, and 6 — Forward.

No. 27.—To Advance from a Flank in Echellon of Sub-Divisions.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Advance from the Right in Echellon of Sub-divisions—March.		In succession—Forward—March.

Advancing from the left is done on the same principle.

A battery in echellon of sub-divisions, if required to change its front when in action, can do so at the words ACTION LEFT (or RIGHT), by merely throwing the trails round, and bringing the guns into the new direction; the limbers and waggons forming in rear of their guns.

No. 28.—To Advance from a Flank in Echellon of Divisions.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Advance from the Right in Echellon of Divisions—March.	(In succession)—Forward—March.	Forward.

Advancing from the left is done on the same principle.

No. 29.—A Battery in Echellon of Divisions to Change its Front when in Action.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Change Front to the Left on the Left Guns of Divisions—March.		Of 2, 4, 6—Action Left. Of 1, 4, 5—Front limber up—Left wheel—Halt —Action Front.

An echellon of half batteries is formed in the same manner as that of divisions; the rear half battery keeping its wheeling distance from the leading one. When in action, if the front is to be changed, it is better to do it on a *centre gun.*

Retirements in echellon are done on the same principle as the advance.

No. 30.—To Retire from a Flank in Column.

First Method.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Right Division to the Rear—March.	Of Right Division—Sub-divisions inwards about Wheel. Of Centre and Left Divisions—Right Wheel—Right Wheel.	Of 1—Right Shoulders. Of 2—Left Shoulders.

Second Method.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Right Half Battery to the rear—March.	Of Right Half Battery—Sub-divisions inwards about Wheel. Of Left Half Battery—Right Wheel—Close Interval—Right Wheel, Full Interval.	Of 1—Forward—Right Shoulders. Of 2—Right about Wheel. Of 3—Left Shoulders.

No. 31.—To Retire from a Flank in Column of Divisions.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Retire from the Right in Column of Divisions—March.	Of Right Division—Right Reverse. Of Centre and Left Divisions — Right take Ground—Right take Ground.	Of 1—Right Reverse. Of 2—Right Reverse—Gun Left—Gun Rear. Of 3, 5, and 6—Right take Ground. Of 4—Right take Ground—Gun Left—Gun Rear.

No. 32.—To Retire from a Flank in Column of Half Batteries.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Retire from the Right in Column of Half Batteries—March.	Of Right Half Battery—Right Reverse. Of Left Half Battery—Right take Ground—Right take Ground.	Of 1 and 2—Right Reverse. Of 3—Right Reverse—Gun Left—Gun Rear. Of 4, 5, and 6—Right take Ground—Right Reverse.

No. 33.—To Retire from the Centre in a Double Column of Sub-Divisions.

In order to perform this manœuvre, the battery should be reversed, *and then* (with waggons leading) it is performed in the same manner as the advance from the centre, in a double column.

No. 34.—To Retire from a Flank by Alternate Half Batteries in Action.

When a battery in line in action is ordered to retire from a flank by alternate half batteries, the whole of the waggons and limbers come up and reverse as for limbering up to the rear, the named half battery limbers up at once and retires on its marker, who will have taken up any distance that may be ordered, the other half battery remains in action, the limbers four yards from the trail, ready to limber up as soon as the named half battery is halted for action.

The senior officer of each half battery gives the word of command.

If the half battery to retire is not specified, the left retires.

No. 35.—To Break into Column to a Flank.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Break into Column of Divisions to the Right—March.		Of 1, 3, 5—Right take Ground—Guns Front. Of 2, 4, 6—Right Wheel.

Breaking into column to the left can be done on the same principle.

A column of half batteries can be formed in the same manner; the pivot sub-divisions wheeling as before, but the others, after taking ground, must incline away to gain their required intervals.

This movement would generally be employed in breaking into column from line with other troops; and with half batteries it would be done at reduced intervals.

It is not necessary to retain the pivot, the words of command will be "Divisions right wheel," and each division wheels on its reverse sub-division.

BATTERY IN COLUMN.

No. 36.—From Column of Route to form Column of Sub-divisions on the March.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Form Sub-divisions.		Of 1—Waggon Right. Of 2, 3, 4, 5, 6—Waggon Right—Trot—Walk.

No. 37.—From Column of Route to form Column of Divisions on the March.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Form Divisions.	Of Centre and Left Divisions—Trot—Walk.	Of 1, 3, 5—Right Incline—Forward.

There are two ways of performing this movement. When the commanding officer wishes to preserve the pivot, he gives the word Form

DIVISIONS (as above); when he does not wish to preserve the pivot, he gives the word FRONT FORM DIVISIONS, upon which the rear sub-divisions of divisions incline at an increased pace towards the pivot flank, the officers and staff-serjeants moving to their position in column of divisions.

The centre and rear divisions, when square, trot up as before.

No. 38.—FROM COLUMN OF SUB-DIVISIONS TO FORM COLUMN OF DIVISIONS ON THE MARCH.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Form Divisions.		Of 1, 3, 5—Right Incline—Waggon Rear—Forward. Of 2, 4, 6—Waggon Rear.

No. 39.—FROM COLUMN OF SUB-DIVISIONS TO FORM COLUMN OF ROUTE ON THE MARCH.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Form Column of Route—Walk.		Of 1, 2, 3, 4, 5—Trot—Waggon Rear. Of 6—Waggon Rear.

No. 40.—FROM COLUMN OF DIVISIONS TO FORM COLUMN OF SUB-DIVISIONS ON THE MARCH.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Form Sub-divisions.	Waggons Right.	Of all—Waggons Right. Of 1, 3, 5—Left Incline—Trot—Walk.

No. 41.—FROM COLUMN OF DIVISIONS TO FORM COLUMN OF ROUTE ON THE MARCH.

Commanding Officer. (Repeated by Officers).	*Officers.*	*Nos.* 1.
Form Column of Route.		Of 1, 3, 5—Left Incline—Trot—Forward—Walk. Of 2, 4—Trot—Walk. Of 6—Forward.

No. 42.—TO BRING THE REAR TO THE FRONT IN SUCCESSION ON THE MARCH IN COLUMN OF ROUTE.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Rear Sub-division to the Front—Walk.		Of 6, 5, 4, 3, 2 (in succession)—Right Incline—Trot—Forward.

No. 43.—To bring the Rear to the Front in Succession on the March in Column of Divisions.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Rear Division to the Front through the Intervals.	Of Rear and Centre Divisions in succession—Inwards Incline—Trot—Forward—Full Interval—Walk.	Of 5, 3, and 1 (in succession)—Left Incline—Trot—Forward—Right Incline—Forward—Walk. Of 6, 4, and 2 (in succession)—Right Incline—Forward—Left Incline—Forward—Walk.

No. 44.—To form Line on the Leading Division.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Front form Line—March.	Of Centre Division—Left take Ground—Right take Ground—Halt—Dress. Of Left Division—Left take Ground—Right Incline—Right Incline—Halt—Dress.	

In performing this movement on the March the centre and rear divisions incline towards the intended line, and come up at an increased pace, staff-serjeants shifting to their places in line as they come up.

No. 45.—From Column of Divisions to form Line for Action.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Front Form Line for Action Front—March.		

No. 46.—To form Line on the Rear Division.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Line on the Rear Division—March.	Of Centre Division—Right take Ground—Right take Ground—Right Reverse—Halt—Dress. Of Right Division—Right take Ground—Right Incline—Right Incline—Right Reverse—Halt—Dress.	Of 1, 2, 3 and 4—Right take Ground.

No. 47.—To form Line on the Rear Division for Action.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Line on the Rear Division for Action—Front—March.		

The rear division comes into action to the front at the word March. *The others, as they arrive in line, come into action at their rear.*

No. 48.—To Form Line on the Centre Division.

This manœuvre is a combination of Nos. 44 and 46.

No. 49.—To Form Line to the Rear on the Leading Division.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Line to the Rear on the Leading Division—March.	Of Right Division—Sub-divisions Inwards About Wheel—Halt—Dress. Of Centre Division—Right take Ground—Left take Ground—Sub-divisions Inwards About Wheel—Halt—Dress. Of Left Division—Right take Ground—Left Incline—Left Incline—Sub-divisions Inwards About Wheel—Halt—Dress.	Of 1—Right Shoulders. Of 2—Left Shoulders. Of 3, 4, 5, and 6—Right take Ground.

No. 50.—Advancing in Column of Divisions to form Line to the Rear on the Leading Division—On the March.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Line to the Rear on the Leading Division.	Of Right Division—Sub-divisions Inwards About Wheel. Of Centre and Rear Divisions—Right Wheel—Right Wheel.	Of 1—Right Shoulders. Of 2—Left Shoulders. Of 3, 4, 5, and 6—Right Wheel.

No. 51.—Retiring in Column of Divisions to form Line to the Rear on the Leading Division—On the March.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Line to the Rear on the Leading Division.	Of Right Division—Right Reverse. Of Centre and Left Divisions—Right take Ground—Waggons Close Interval—Right take Ground.	Of 1 and 2—Right Reverse. Of 3, 4, 5, and 6—Right take Ground.

No. 52.—Form line to the Rear on the Rear Division.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Line to the Rear on the Rear Division—March.	Of Right Division—Left Wheel—Half Left—Left—Halt—Dress. Of Centre Division—Left Wheel—Left Wheel—Halt—Dress. Of Left Division—Sub-divisions Inwards About Wheel—Halt—Dress.	Of 5—Right Shoulders. Of 6—Left Shoulders.

No. 53.—To Form Line to the Rear on the Centre Division.

Is a combination of Nos. 51 and 52.

No. 54—To Form Line to the Reverse Flank on the Leading Division.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Line to the Right on the Leading Division—March.	Of Right Division—Right Wheel—Halt—Dress. Of Centre and Left Divisions—Forward—Right Wheel—Halt—Dress.	Of 2, 3, 4, 5, and 6—Forward.

No. 55.—To Wheel into Line.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Left Wheel into Line—March.		Of 1, 3, 5—Left Wheel—Halt—Dress. Of 2, 4, 6—Right Wheel—Right about Wheel—Halt—Dress.

No. 56.—To Deploy on the Rear Division.

N.B.—All deployments are on the front base.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Deploy on the Rear Division—March.	Of Right Division—Right take Ground—Right take Ground—Right Reverse—Halt—Dress. Of Centre Division—Right take Ground—Left take Ground—Halt—March—Halt—Dress. *Of Left Division*—Forward—March—*Halt—Dress.*	Of 1, 2, 3 and 4—Right take Ground. Of 5 and 6—Forward.

No. 57.—TO DEPLOY ON THE REAR DIVISION FOR ACTION.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Deploy on the Rear Division for Action—Front — March.	Of Right Division — Right take Ground—Halt—Action Left. Of Centre Division — Right take Ground—Left take Ground—Halt —March—Halt—Action Front. Of Left Division—Forward—March —Halt—Action Front.	Of 1, 2, 3, and 4—Right take Ground. Of 5 and 6—Forward.

No. 58.—TO DEPLOY ON THE CENTRE DIVISION.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Deploy on the Centre Division—March.	Of Right Division — Right take Ground — Right take Ground — Right Reverse—Halt—Dress. Of Centre Division — Forward — March—Halt—Dress. Of Left Division—Left take Ground —Right take Ground — Halt — Dress.	Of 1 and 2—Right take Ground. Of 3 and 4—Forward. Of 5 and 6—Left take Ground.

No. 59.—ADVANCING IN COLUMN OF DIVISIONS TO DEPLOY ON THE REAR DIVISION ON THE MARCH.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
Deploy on the Rear Division.	Of Right and Centre Divisions—Right take Ground — Waggons close Interval—Left take Ground.	Of 1, 2, 3 and 4—Right take Ground.

No. 60.—TO COUNTERMARCH A COLUMN OF DIVISIONS.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos. 1.*
The Column will Countermarch—March.	Sub-divisions Inwards About Wheel—Halt —Dress.	Of 1, 3, and 5—Right Shoulders. Of 2, 4, and 6—Left Shoulders.

On the March.—The divisions wheel about inwards by sub-divisions, and move forward without halting. Officers and staff-serjeants turn right about. A column of half batteries countermarches by each half battery wheeling about inwards by sub-divisions. Markers mark for the pivot guns of half batteries.

No. 61.—From Double Column of Sub-divisions to form Line to the front.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Front Form Line—March.	Of Right Division—Right Incline. Of Left Division—Left Incline.	Of 1 and 2—Right Incline — Forward — Halt—Dress. Of 5 and 6—Left Incline — Forward — Halt—Dress.

On the March.

The rear sub-divisions move up at an increased pace.

For Action.

At the word March, the two leading sub-divisions come into action to the front; the other sub-divisions come into action in succession, as they arrive in line.

No. 62.—From Double Column of Sub-divisions to form Line to a Flank.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Line to the Right on the Right Half Battery—March.	Of Centre Division—Right Wheel—Halt—Dress.	Of 1, 2, 5, and 6—Forward — (in succession) — Right Wheel — Halt — Dress.

No. 63.—From Double Column of Sub-divisions to form Line to a flank for Action.

Commanding Officer. (Repeated by Officers.)	*Officers.*	*Nos.* 1.
Line to the Right for Action Right—March.	Of Right and Left Divisions—Forward.	Of 1—Forward — Waggon Left—Halt—Action Right. Of 2 — Forward—Waggon Left — Halt—Action Front. Of 3—Halt—Action Right. Of 4, 5, and 6— Forward—Right Wheel—Halt—Action Front.

Section III.—Inspection, and Review.

The battery is formed, in line limbered up, the detachments mounted.

A Single Battery. The waggons at order, viz., ten yards in rear of the guns. The officers at order, viz., the subalterns one horse's length in front of the centre of their divisions, the second captain on the right of the battery in line with the subalterns.

The Captain gives the Command "Officers Advance to Order," "March."

The assistant surgeon and veterinary surgeon one horse's length on the right of the leaders of the guns.

Trumpeters one horse's length on the right of the whole, in line with the leaders of the guns.

The captain in the centre, half a horse's length in front of the subalterns.

The commanding officer two horses' lengths in front of the captains of batteries.

A Brigade of Batteries.

The adjutant on the right of the line, in line with the subalterns.

The staff officers on the right, in line with and one horse's length from the leaders of the guns.

The serjeant-major in line with the leaders of the guns covering the adjutant.

"General Salute." "Draw Swords."

As the inspecting officer arrives, the commanding officer gives the word, "General Salute," "Draw Swords." Officers and mounted non-commissioned officers draw swords, the officers coming down at the last motion to the salute.

If done by trumpet, the swords are drawn at the last sound of the call.

The officers recover and carry swords, taking the time from the commanding officer.

The commanding officer accompanies the inspecting officer, and the whole remain steady while he makes his inspection. Captains will give the word "Eyes right," or "left," as the inspecting officer comes to their batteries, "Eyes front" when he has passed.

"Slope Swords," "Close Order."

As soon as the inspection has been made the commanding officer gives the word "Slope Swords," "Close order, March," the waggons move up to close order: subalterns remain steady.

MARCHING PAST.

A Battery to march past in Line at Close Intervals.

Words of Command. (The Captain, repeated by Officers.) The Battery will march past at close interval "Right take Ground." "Walk-March."

At the word "March" the battery takes ground to the right; when the head of the column arrives at the first wheeling point the captain gives the word "Left wheel;" when the head of the column arrives at the second wheeling point, the captain gives the word "Left take ground, close interval on No. 1," upon which the rear sub-divisions incline to their right after taking ground, and move up to close intervals, subalterns taking post one horse's length in front of their divisions.

"Left Wheel." Left take Ground, close

On arriving at the open order point, 40 yards from the inspecting officer, the captain gives the word "Take Order," followed by "Carry Swords," "Eyes Right," upon which the waggons check the pace until the heads of

on the leaders are 10 yards distant from the guns: the drivers salute.

Order," *Swords."* *Right."* At 10 yards from the inspecting officer the officers salute, subalterns taking the time from the captain, who is one horse's length in front of them. on as the captain has passed the inspecting officer he places himis right and carries his sword; at 10 yards past the inspecting ie subaltern officers recover and carry their swords.

the rear of the battery has passed the inspecting officer the ejoins his battery, and at the close order point, 50 yards from the inspecting officer gives the word "Slope

Swords," *Order."* Swords," "Close Order," upon which the drivers throw back their whips, and the waggons trot up to close order.

rjeant-major marches past in rear of No. 1 sub-division, quarr-serjeant in rear of No. 6 sub-division, trumpeters 10 yards of the captain, the second captain in rear of the whole.

Vheel." *Wheel."* At the third wheeling the captain gives the word "Left wheel," and again at the fourth wheeling point.

ons do not take order when the front is less than that of a

RANKING PAST.

The battery is halted at the open order point.

aptain gives the word "The battery will rank past," upon

'attery *k past."* which No. 1 of the right sub-division places himself a horse's length in front of his sub-division, the subaltern of the right division one yard in front of 1, and the captain one yard in front of the subaltern, trumfront of the whole. The second captain, or in his absence the major, places himself on the right of and facing the battery, at the

Swords." *' "March."* *Right."* open order point; the captain then gives the word "Carry Swords," "Walk," "March;" at the word "March," the right sub-division moves off, No. 1 giving the word "Eyes Right" for the drivers to The remaining sub-divisions receive the word from their "Right Incline," "Walk," "March," in succession, and follow ; sub-division, the officers and Nos. 1 placing themselves as der the right sub-division.

fficers salute in succession when within ten yards of the in- officer. The captain takes post as before on his right. At the ieeling point the leading sub-division is halted, and the battery d at close intervals.

iarkers rank past in front of their waggons, the farrier in front rge, the quartermaster-serjeant in rear of the rear carriage, the major in his rear, the second captain in rear of the whole.

yards' distance *is kept in* front and rear of each carriage, and *from nose to croup* between single horses.

TROTTING PAST.

"The Battery will trot past—March." The captain gives the word, "The battery will trot past—March."

"Carry Swords," "Eyes Right." "Slope Swords." At the open order point, the captain gives the word "Carry Swords," "Eyes Right." At the close order point "Slope Swords."

Waggons do not take order in trotting past.

Spare carriages do not trot past.

ENCAMPING, AND PICKETING.

There are various methods of encamping, and picketing, but as it depends so much on local circumstances, it will be sufficient to point out in what manner a battery is generally drawn up for that purpose, and to detail the numbers employed in the different duties.

Experience has shown that whenever Artillery can make use of their carriages, they should not use the picket posts, which are difficult to drive in hard ground, and easily drawn out in wet or sandy ground; it has always been found that fastening the picket lines to the wheels of the different carriages is both the quickest and safest way of securing the horses.

To encamp and picket expeditiously and regularly requires close adherence to the system laid down, and therefore the duty of each man is distinctly defined.

First Method.

BATTERY IN LINE AT HALF INTERVALS.

Prepare to Encamp, and Picket. The staff-serjeants mark for the line of pickets on the front base facing the alignment at one half interval from the flank sub-divisions.

The gun detachment take the tent and peg bags, tent poles, and picket posts off the waggon.

Nos. 2, 4, and 6 of each sub-division, and No. 8 of Nos. 1 and 6 sub-divisions take a picket post each (20 for the battery).

No. 9 takes a maul, and the centre gun driver a picket-rope.

Three ropes are required on each flank of the battery.

Nos. 1 and 3 of the two centre sub-divisions, and Nos. 1, 3, and 5 of the other four sub-divisions, take a tent pole each (16 in all) and put them together for the men's tents, 8 on each flank.

No. 5 of No. 3 sub-division puts a tent pole together for the guard tent, No. 7 of each sub-division adjusts tent poles for the six officers' tents.

The odd numbers carry tent poles, the even numbers picket posts.

Drivers dismount, and unhook.

"Encamp, and Picket." The whole stand steady till the word is given to "Encamp, and Picket."

Nos. 2, 4, 6, and 9 of the right half-battery, and No. 8 of No. 1 sub-division double up to the serjeant-major on the right front, the corresponding numbers of the left half battery double up to the quartermaster-serjeant on the left front, and place themselves in single file from the front base facing to the rear, except Nos. 6 of the two centre sub-divisions (who carry an extra picket post for securing the end of the line on the front base, and who wait to have their posts driven after those of Nos. 2 of the centre sub-divisions are driven), and Nos. 9, who fall in with their mauls on the inner flank of Nos. 2.

Nos. 2 of the centre sub-divisions place themselves in front of the alignment next to the staff serjeants. Nos. 9 on their inner flank and 6 on their outer flank; Nos. 4 of the centre sub-divisions in front of Nos. 2.

Nos. 2, 4, and 6 of Nos. 2 and 5 sub-divisions fall in, in single file from lowest to highest, facing to the rear in front of Nos. 4 of the centre sub-divisions. Nos. 9 on the inner flank of Nos. 2.

Nos. 2, 4, and 6 of the flank sub-divisions in single file in front of Nos. 6 of Nos. 2 and 5 sub-divisions, Nos. 6 leading to the rear. Nos. 9 on the inner flank of No. 2, and No. 8 on the outer flank of No. 6.

At the same time, Nos. 1 and 3 of the centre sub-divisions, and Nos. 1, 3, and 5 of the remaining sub-divisions double up with their tent poles, and fall in in single file from the front base facing to the rear, at a half interval (9½ yards) outside the picket men on each flank of the battery, so that Nos. 1 of the two centre sub-divisions dress by Nos. 6, 2, and 9, and Nos. 3 by No. 4.

Nos. 1 of Nos. 2 and 5 sub-divisions dress by Nos. 2 and 9, Nos. 3 by Nos. 4, Nos. 5 by Nos. 6.

Nos. 1 of the flank sub-divisions dress by Nos. 2 and 9, Nos. 3 by Nos. 4, Nos. 5 by Nos. 6 and 8.

The subaltern officers see that both the picket and tent pole numbers cover correctly, and are responsible for the correct intervals and dressing of tents and picket posts.

As soon as all cover correctly, the second captain gives the word "Quick March," Nos. 1, 2, 6, and 9 of the centre sub-divisions stand fast. The remainder step off together, the rear file being halted at every eleventh pace by a staff-serjeant, who rides down alongside of him, between the post and pole numbers, counting the paces.

As soon as he has halted, Nos. 5, 6, and 8 on the rear base, he returns to the front base, the word "Front," is given by the second captain, and the subaltern officers correct the covering and dressing, taking care that the line of posts and tent poles is at right angles to the base, and parallel to the flank sub-divisions.

When all are posted, there will be two picket posts at the end of each line of pickets on the front and rear base, and a picket post corresponding to a tent pole at every half interval from front to rear.

At the same time that the tent and picket numbers double to the flanks on the words "Encamp, and Picket," No. 5 of No. 3 sub-division doubles to the front, and places himself one interval in front of the centre, holding the tent pole for the guard tent.

Nos. 7 of each sub-division at the same time double with tent poles to the rear centre of the battery. No. 7 of No. 3 sub-division places himself one half interval in rear of the third line of carriages covering the guard tent. No. 7 of No. 4 sub-division covering him half an interval further to the rear. No. 7 of No. 2 sub-division will dress by No. 7 of No. 3, placing himself half an interval on the right, No. 7 of No. 5 sub-division, dressing by them half an interval on the left.

No. 7 of No. 1. and No. 7 of No. 6, dressing by No. 7 of No. 4, and covering respectively Nos. 7 of 2 and 5 sub-divisions.

As soon as the picket and tent numbers have taken their position, the 2nd captain will correct the dressing from the right flank, taking care that Nos. 3 and 4 of the flank sub-divisions and Nos. 7 of 2 and 5 sub-divisions are parallel to the front; and that Nos. 5, 6, and 8 of the flank sub-divisions and Nos. 7 of 1, 4, and 6 sub-divisions are correctly dressed at a half interval further in the rear.

The centre gun drivers carry the picket rope for each sub-division to No. 2 of their own sub-division, and return to their horses. As soon as the points are dressed, the picket posts are driven under the superintendence of the subaltern officers of the flank divisions.

Nos. 8 of 2, 3, 4, and 5 sub-divisions unroll and make fast the line, taking two half-hitches round each post above, and below the ring.

The subaltern officers on either flank report to the captain as soon as the rope is made fast, and he orders the horses to file on the pickets.

The subalterns are responsible that they file off in order, the flank sub-division moving first, each team wheeling outwards, the horses of the 3rd line of carriages leading to the rear.

Nos. 2 and 5 sub-divisions wait till the gun-horses of Nos. 1 and 6 have passed their 3rd line of carriages in moving to the rear; each team then wheels outwards and moves along the front of the line of carriages to which it belongs, to its place in the pickets.

The centre division waits till the horses of 2 and 5 sub-divisions have moved off.

Each sub-division occupies a front of 19 yards, subdivided into two half intervals by a picket post in the centre.

In the left half battery the ride and spare horses will be on the left when picketed, the gun horses on the right of each sub-division. In the right half battery the spare horses on the right, and gun horses on the left.

The last half interval to the rear is for officers' and staff horses.

The subalterns of the flank divisions superintend the filing, and picketing. The second captain and junior subaltern, assisted by the staff serjeants, attend to the pitching of the tents, which is going on while the picket posts are being driven.

The horses are fastened by the centre of the collar-chain to the picket line, taking two half hitches round it, the T-end passed through the large link.

As soon as the first picket posts are driven, Nos. 2 bring up the peg *bags and* wallets of the half batteries on each flank, and drive a peg to

ıark the centre of each tent; after which they assist Nos. 4 and 6 in ringing up the tents of each half battery.

Nos. 8, as soon as they have assisted in fastening the picket rope, arry the officers' tents to the rear, and drive a peg to mark the centre f each tent, as soon as the second captain has finally dressed Nos. 7 rith the tent poles.

Nos. 5 of No. 4 sub-division carries out the guard tent as soon as he word to encamp is given.

As soon as the centre of each tent is marked by a peg, four guy pegs re driven to the front, rear, right, and left at three yards from the entre peg. The tents are then spread out by all the available numers, the second cord from each side of the door being fixed to the ront peg, the fifth cord on each side of them to the two side pegs, and he rear cord to the rear peg.

The original tent pole numbers, viz., Nos. 1 and 3 of the two centre ub-divisions, and Nos. 1, 3, and 5 of the remaining sub-divisions, esides No. 5 of No. 3 sub-division for the guard tent, and Nos. 7 for he officers' tents, then place the poles home in the canvas, and prepare o raise tents.

As the tents lie on the ground previous to raising, the foot of the ole is laid in the direction corresponding with the doorway, which, rith the curtain, is hooked and kept uppermost.

The guard tent opens to the front. All other tents face the battery.

'Prepare to aise Tents." 'Raise Tents." At the word "Prepare to raise tents," the tent pole numbers stand ready to raise the tent. At the word or sound, the other pegs, one opposite each seam, are driven, and the cords fastened to them.

The following is the distribution of tents to each division :—

Right Division; 2 Officers' and 6 men's tents.
Centre do. 2 Officers', 4 men's, and 1 guard tent.
Left do. 2 Officers' and 6 men's tents.
TOTAL, 23 tents.

Each sub-division pitches and occupies the tents it carries, and the ıon-commissioned officers and men are opposite to their horses when icketed.

The harness is placed in line behind the horses, one yard from the arriages. The traces, breeching, and collars are put inside the pad, which is laid inside the saddle, and the whole is kept compact by uckling the surcingle of the saddle round it; the bridles are laid ver the cantles, which are towards the horses, numnah or blanket ver all.

'Prepare to trike Tents, nd Pickets." The quickness with which this can be done depends upon each number performing in inverse order the duties allotted to him in encamping. The pickets are struck at once, the horses are filed on the carriages nd hooked in, the centre sub-divisions leading.

The tents are prepared for striking by drawing all the pegs except he four guy pegs.

"Strike Tents." When all the tents are ready to strike, the tent pole numbers stand to the poles ready to lower the whole together at the word, or sound.

Subaltern officers report as soon as their divisions are hooked, and the carriages packed.

A battery encamped on this plan occupies a perfect square, the side of which is 85½ yards, or 9 half intervals.

The carriages can also be drawn up at full, or in limited space at quarter interval, without altering the space occupied by the men's tents, or pickets, and with the same detail of duties.

Second Method.

BATTERY IN COLUMN OF SUB-DIVISIONS.

This system, for celerity, economy of labour, and convenience, is perhaps superior to any other for a temporary encampment. It also occupies a comparatively small space, and the guns can be quickly brought into action at full interval.

The battery is formed to either flank as may be required in column of sub-divisions, taking care that the waggon forms up square so as to leave a full interval of 19 yards between it and the gun.

All general directions are the same as already laid down.

"Prepare to Encamp, and Picket." Nos. 1, 3, 5, and 7 of every sub-division take a tent pole and put it together, except No. 5 of No. 4 sub-division, who assists No. 5 of No. 3 in pitching the guard tent.

Nos. 9 take a maul and picket post each.

The centre drivers of guns take a picket line each. One is required for each sub-division.

"Encamp, and Picket." Nos. 1 of each sub-division place themselves in a line with the muzzle of the gun at one half interval in rear of the third line of caariages, facing the head of the column.

No. 3 of each sub-division places himself half way between No. 1 of his own and No. 1 of the sub-division in his front, so that these tent pole numbers will be in single file facing the head of the column, with half an interval between each pole.

There will thus be a line of twelve tents for non-commissioned officers and men, two immediately facing each sub-division.

No. 5 of No. 3 sub-division places himself two yards behind the muzzle of No. 3 gun, and one interval from the outer flank of the column, which will be the real front of the encampment, facing about to ascertain that he is correctly at right angles to the battery.

No. 5 of No. 1 sub-division places himself at half an interval on the right of No. 3 of No. 3 sub-division; No. 5 of No. 2 sub-division on the right of No. 1 of No. 3 sub-division; No. 5 of No. 5 sub-division on the right of No. 3 of No. 4 sub-division; No. 5 of No. 6 sub-division on the right of No. 1 of No. 4 sub-division; all facing the head of the column, and each dressing at half interval from the number on his flank, and covers at half interval the number in his front.

Nos. 7, who carry the officers' tent poles, take up their position, facing the head of the column, at half an interval on the right of the second line of tents, so that No. 7 of No. 1 sub-division will be a full interval on the right of No. 1 of No. 2 sub-division, and No. 7 of No. 6 a full interval on the right of No. 3 of No. 5 sub-division, the Nos. 7 of 2, 3, 4, and 5 sub-divisions at half interval on the right of the four tent poles of the second line of tents.

The subalterns dress and correct the line of tents, the second captain superintending.

The centre of each tent is marked and the pegs driven, as before directed. Nos. 2, 4, 6, and 8 of each sub-division carry out the tents to 1, 3, 5, and 7; 2 assisting 1, 3 assisting 4, and so on.

No. 5 of No. 4 sub-division carries out the guard tent to No. 5 of No. 3 sub-division.

Nos. 6 of 3 and 4 sub-divisions assist Nos. 9 in driving the picket posts half way between the hind axletree of the gun and waggon in each sub-division, and securing the ends to the gun and waggon wheel, after taking two half-hitches round the picket post, above and below the ring.

Officers' horses are on the right flank, led horses of the gun on the left flank of the picket.

Should the depth be limited, the third line of carriages can be drawn up at quarter interval on the ammunition waggons.

If the front of the encampment is limited in space, and there is depth to the rear, carriages can be drawn up with the head of the column towards the guard tent, and the guns on the outer flank of the encampment.

EMBARKING, AND DISEMBARKING.

The following directions will be found applicable to nearly all the cases likely to occur; such as embarking, or disembarking from a beach; from a wharf; with, or without boats; in presence of an enemy, &c., &c.

Embarking Guns, and Carriages.

1. On the arrival of the battery at the place of embarkation, it is to be drawn up in as compact order as is consistent with the performance of the operations required. The horses are to be taken out; the harness taken off and packed in vats, and the stores in cases. When there are no vats and cases the stores must be secured to the carriages or tied together: the intrenching tools may remain with the carriages. The non-commissioned officers in charge of sub-divisions will attach to their harness and stores pieces of basil having the number of their sub-divisions written upon them. The harness for each carriage should be embarked with it.

2. The *gun detachments will* prepare the carriages for embarkation. *They will take off the side arms* and secure them together, take out the

inches long and three feet ten inches wide, placed on runners sixteen inches high; upon this rest two strong transoms, to which the brackets supporting the gun are secured. A box distinct from the ammunition boxes, is placed on each side of the gun, together capable of containing about thirty rounds of ammunition, and which serve as seats. These boxes usually contain the shot and small stores carried in the axletree boxes, as well as long reins for driving, when in single draught.

The manner in which a gun with its ammunition is arranged on the sleighs is as follows:—

Three sleighs form one sub-division.

On the first is mounted the gun, with its side arms, slow match box, and portfire cutter.

The front box of the waggon body and the gun limber boxes are carried on No. 1 ammunition sleigh.

On No. 2 ammunition sleigh the rear box of the waggon body and the waggon limber boxes are placed.

The knapsacks are carried on the ammunition sleighs.

If the roads are good, two horses are sufficient for each sleigh; but four horses are usually put to the gun, and two to each of the ammunition sleighs. This arrangement is only suitable for parade and exercise on good roads, as the gun is the lightest of the three sleighs which compose a sub-division.

Hooking in.

When a battery is ordered out, the detachments form the order of march, as with wheel carriages, and shift after hooking in. When about to be dismissed, the men shift again, so as to be on their proper sides for unhooking.

Nos. 2, 3, 4, and 5 hook in horses of gun sleigh.

Nos. 6 and 7 those of No. 1 ammunition sleigh.

Nos. 8 and 9 those of No. 2 ammunition sleigh.

Posts of the Detachments with Sleigh Carriages.

The position of a gun on a sleigh being reversed, (*i.e.*, the muzzle to the front instead of to the rear,) it becomes necessary to alter the positions of the detachment, that each man may find himself on his proper side of the gun when it is brought into action.

The odd numbers or front rank will be on the left or near side; the even numbers or rear rank on the right or off side. Nos. 1 at the horses' heads; 2 and 3 in line with the muzzle; 4 and 5 in line with the breech; 6 and 7 one yard in rear of 4 and 5; 8 and 9 one yard in rear of 6 and 7.

No. 1 on the left, and No. 6 on the right of the gun sleigh; 3 on the front box of No. 1 ammunition sleigh; 4 and 5 on the rear box of No. 1 ammunition sleigh, 4 on the right, 5 on the left; 2 on the front box of No. 2 ammunition sleigh; 7 and 8 on the rear boxes of No. 2 ammunition sleigh, 7 on the left, 8 on the right; 9 on the front box of No. 1 ammunition sleigh.

Coming into Action.

No. 1 unhooks the swingletree, places it on the back of the near horse, then steps in and takes hold of the shafts on the near side; 6 takes hold of the shafts on the off side, and the two numbers lift them off, laying them gently on the ground; 3, as soon as he comes up, places the hook of the swingletree in the crupper ring, hook upwards. No. 1 gives the word "Drive On," when all is ready. In coming into action to the front, or to the right, the gun horses move to the left, and form on the left of No. 1 ammunition sleigh. In action left, they move to the right, and form on the right of the same sleigh.

Limbering up.

This is done by the Nos. who unlimbered. The waggon sleighs (which in action are at the distance of ten yards from the gun) close up to three yards' distance.

Marching Order.

In marching order the following stores and intrenching tools are on the gun sleighs: two fitting ropes, one spare swingletree; two swords on front platform under breast of gun, claw hammer, wrench and pincers; in sockets two portfire sticks on right rear of platform.

On No. 1 ammunition sleigh: two fitting ropes, prolonge, two spare swingletrees, and one sword on front part of platform; two carbines on front box, spare sponge and worm on platform right of boxes; spare handspike on left side; four spare traces between front and rear boxes; two swords, on platform in rear of boxes, covered by four knapsacks. The knapsacks are strapped from off-handle of off-box to near handle of near box.

On No. 2 sleigh: felling axe and two camp kettles on front of platform; one sword on front box; pickaxe in rear of front box; four spades strapped to front of rear boxes; four water buckets strapped to guardirons of front box, two at each side; two swords in rear of boxes, covered by four knapsacks.

AMMUNITION WAGGON FOR 12-POUNDER (8 CWT.) ARMSTRONG GUN.

Mode of Packing Ammunition and Stores.

LIMBER.

1 Felling Axe. 1 Picket Line. 1 Pair of Drag Ropes. 1 Lifting Jack.

NEAR BOX.

1 Swingletree. 1 Hand Bill.

1 Grease Box, cont. 3 lbs. grease.

MID BOX.

OFF BOX.

Near Box: 1 Shovel. — 1 skein of marline. 15 segment shells with bursters, shell plugs, and plugs covered with serge. 1 canvas cartouch. 15 1½lb. cartridges with lubricating wads. 1 leather cartouch. 25 brass tubes in zinc cylinder. 4 portfires—on lid.

Mid Box: 1 tin box containing 100 friction tubes. 5 tin boxes cont. in all 30 concussion fuzes, and 15 time fuzes.

Off Box: 1 skein of Hambro' line. 15 segment shells with bursters, shell plugs, and plugs covered with serge. 1 leather cartouch. 1 tube pocket with strap. 1 canvas cartouch. 15 1½lb. cartridges with lubricating wads. — 1 Spade.

1 Water Bucket. Drag Shoe. 1 Pick Axe. 1 Water Bucket.

WAGGON BODY. 28 lbs. Grease, in Magazines.

Box, cont. 10 sets of Horse Shoes, and a proportion of Nails.

(FORE.) 1 Linchpin. 1 Drag Washer. 1 Hand Saw in Leather Case. 2 Couples for Traces.

Fore, near side: 15 segment shells with bursters, shell plugs, and plugs covered with serge. 1 canvas cartouch. 15 1½lb. cartridges with lubricating wads.

Fore, middle: 5 tin boxes cont. in all 30 concussion fuzes, and 15 time fuzes.

Fore, off side: 15 segment shells with bursters, shell plugs, and plugs covered with serge. 25 empty flannel cartridges and lubricating wads. 1 canvas cartouch. 15 1½lb. cartridges with lubricating wads.

2 Sets of Tent Poles. 2 Bags of Tent Pins. 2 Circular Tents. 4 Reaping Hooks. 2 Bags of Tent Pins. 2 Sets of Tent Poles.

Hind, near side: 3 lbs. slow match. 15 segment shells with bursters, shell plugs, and plugs covered with serge. 1 canvas cartouch. 15 1½lb. cartridges with lubricating wads.

Hind, middle: 5 tin boxes cont. in all 30 concussion fuzes, and 15 time fuzes.

Hind, off side: 15 segment shells with bursters, shell plugs, and plugs covered with serge. 1 canvas cartouch. 15 1½lb. cartridges with lubricating wads. 3 lbs. slow match.

Box, containing 10 sets of Horse Shoes and a proportion of Nails. (HIND.) 1 Spare Wheel. Box, containing 10 sets of Horse Shoes and a proportion of Nails.

1 Camp Kettle. 1 Maul. 1 Camp Kettle.

1 Circular Tent on footboard. 1 Circular Tent on footboard.

The first line of Waggons *only* carries Spare Wheels, Hand Saws, and Reaping Hooks.

4 Spare Splinter Bars, 2 Perches, and 4 pairs of Shafts, per Battery, are distributed among the Waggons and lashed under them for transport.

2 Carbines strapped in front, and Blankets, Blanket Covers, and 2 Corn Sacks strapped on the Lids of the Ammunition Boxes.

FOR A LIGHT 6-POUNDER GUN.

'ode of Packing Ammunition and Stores belonging to the Gun, Carriage, and Limber.

Felling Axe.
'rease Box, containing 3 lbs.
NEAR BOX.

LIMBER.
Pair Drag Ropes.

Hand Bill.
Swingletree.
OFF BOX.

Near Box.

'ASE SHOT 'unnels. 'oox, blue, 'n. 12 Shr. 'izes. 'nife. 'nallet. 'etter. 'needles. 'xtractor. 'cissors. 'z. worst. set fuze orers and its. 'rift. strap for 'ize box.	1 cartouch. 8 ROUND SHOT. 13 1¼lb. CARTRIDGES. 6 portfires on lid. 2 keys. 1 driver. 1 box con. 3 each fuze and loading hole plugs and 34 loading hole wads.	8 SHRAPNEL. 1 cartouch. 9 1¼lb. CARTRIDGES. 8 10 drm. bursters. 5 copies of Instructions for fixing fuzes. 2 ditto for shells. 5 fuze sections.

Water Bucket.

Prolonge.

Mid Box.

1 dr. washer.
1 linchpin.
2 couples.
1 ram head.

Off Box.

8 ROUND SHOT. 11 1¼lb. CARTRIDGES. 1 cartouch.	8 ROUND SHOT. 13 1¼lb. CARTRIDGES. 1 cartouch.	4 CASE SHOT 1 tube pocket with strap. 100 friction tubes in zinc cylinder. 3 lanyards.	Spade.

Pick Axe. Water Bucket.

TRAIL.

2 Portfire sticks.
Spare Sponge and Handspike and Wadhook underneath the Trail.
Handspike
Drag Shoe.
Sponge.

NEAR, OR RIGHT AXLETREE BOX.

1 CASE SHOT.	1 CASE SHOT.	1 CASE SHOT.
3 ROUND SHOT.		

Camp Kettle.

OFF, OR LEFT AXLETREE BOX.

1 pun. for shells. 2 pun. for vent. 2 com. spikes. 1 spring ditto. 1 sponge head. 2 thumb stalls. 1 tangent screw. 1 set priming irons.	3 lbs. slow match.

Camp Kettle.

Pincers.
Spanner.
Claw Hammer.

GUN.

Carbines strapped *in front*, and **Blankets, Blanket Covers, and 2 Corn Sacks on the** *Lids* of the **Ammunition Boxes.**

FOR THE AMMUNITION WAGGON OF A LIGHT 6-POUNDER GUN.

Mode of Packing Ammunition and Stores.

Picket Line. Felling Axe. LIMBER. Hand Bill.
Grease Box, cont. 3 lbs. Lifting Jack. Swingletree.
NEAR BOX. Pair Drag Ropes. OFF BOX.

Shovel.

4 ROUND SHOT (above). 4 CASE SHOT. (below). 6 portfires (on lid).	8 ROUND SHOT. 1 cartouch. 12 1¼lb. CAR-TRIDGES.	8 SHRAP-NEL. 1 cartouch. 12 1¼ lb. CARTRIDGES. 8–10 drm. bursters. 1 blue box, containing 12 Shrapnel fuzes. 1 strap for fuze box.	MID-BOX. 1 dr. washer. 1 linchpin. 2 couples.	8 ROUND SHOT. 12 1¼lb. CAR-TRIDGES. 1 car-touch.	8 ROUND SHOT. 12 1¼lb. CAR-TRIDGES. 1 cartouch.	4 ROUND SHOT (above). 4 CASE SHOT (below). 100 friction tubes in zinc cylinder. tube pocket and strap.

Spade.

Water Bucket. Pick Axe. Water Bucket.

Drag Shoe. PERCH.
Spare Wheel, (on Perch).

WAGGON BODY.

FORE BOX.

2 Tents, with Poles, Pins, and Bags complete, and 2 Picket Posts.
Box, cont. 10 sets of Horse Shoes and proportion of Nails.

28 ROUND SHOT in 2 tiers. 12 1¼lb. CAR-TRIDGES. 1 cartouch.	10 SHRAPNEL. 1 cartouch. 10-10 dr. bursters. 16 1¼lb. CAR-TRIDGES. 1 blue bag, cont. 12 Shrap. fuzes. 50 friction tubes in zinc cylinder. 50 brass tubes in do.	15 ROUND SHOT. 27 1¼lb. CARTRIDGES. 1 cartouch. 1 skein of marline.

Box, cont. 10 sets of Horse Shoes and proportion of Nails.
2 Tents, with Poles, Pins, and Bags complete, and 2 Picket Posts.

HIND BOX.—4 Reaping Hooks between the Boxes.

Hand Saw in Leather Case.

15 ROUND SHOT. 27 1¼lb. CARTRIDGES. 1 cartouch. 100 empty flannel cartridges. 6 lbs.	10 ROUND SHOT. 18 1¼lb. CARTRIDGES. 1 cartouch. 1 skein of Hambro' line. Slow	30 ROUND SHOT, in 3 tiers. Match.

2 Grease Magazines, each cont. 14 lbs. Box, cont. 10 sets of Horse Shoes and
Camp Kettle. Maul. Camp Kettle. [proportion of Nails.

The first line of Waggons *only* carries Spare Wheels, Hand Saws, and Reaping Hooks.

4 Spare Splinter Bars, 2 Perches, and 4 pairs of Shafts, per Battery, are distributed among the Waggons, and lashed under them for transport.

2 Carbines strapped in front, and Blankets, Blanket Covers, and 2 Corn Sacks strapped on the Lids of the Ammunition Boxes.

FOR A 12-POUNDER HOWITZER.

de of Packing Ammunition and Stores belonging to the Howitzer, Carriage, and Limber.

LIMBER.

Pair Drag Ropes.

Felling Axe. Grease Box, cont. 3 lbs. NEAR BOX.			OFF BOX. Hand Bill. Swingletree.	
12 SHRAPNEL, in 2 tiers. 1 blue box and 1 blue bag of Shrapnel fuzes, 12 in each. 2 funnels. 1 knife. 1 mallet. 1 setter. 2 needles. 1 extractor. 1 scissors. 2 oz. worsted. 1 set of fuze borers and bits. 2 keys. 1 driver. 1 strap for fuze box. 2 boxes cont. wads and plugs.*	6 SHRAPNEL. 18 1¼lb. CARTRIDGES. 1 cartouch. 18-20 drm. bursters. 5 copies of Instructions for fixing fuzes. 2 do. for shells. 2 drifts. 5 fuze sections. 6 portfires on lid.	Prolonge. MID BOX. 1 drag washer. 1 linchpin. 2 couples.	2 COMMON SHELLS. 4 CASE SHOT. 18 1¼lb. CARTRIDGES. 1 cartouch. 14 6 oz. bursters.	12 COMMON SHELLS in 2 tiers. 1 tube pocket and strap. 1 zinc cylinder cont. 100 friction tubes. 1 black box cont. 8 common fuzes. 1 black bag cont. 16 common fuzes. 3 lanyards. 2 boxes cont. wads and plugs.†

Spade.

Water Bucket. Pick Axe. Water Bucket.

TRAIL.

		* 1 large box	† 1 small box.	2 large boxes each
Plugs	Fuze hole common	—	—	5
	Fuze hole diaph.-Shrap.	12	—	—
	Loading hole diaph.-Shrap.	—		—
Wads	Fuze hole, common	—		54
	Loading hole diaph.-Shrap.	—	130	—

Handspike. Spare Sponge. Handspike and Wadhook underneath the Trail. 2 Portfire Sticks.

NEAR, OR RIGHT AXLETREE BOX.

1 rammer head.
1 set of priming irons.
1 sponge head.

Drag Shoe. Sponge. Pincers. Spanner. Claw. Hammer.

OFF, OR LEFT AXLETREE BOX.

1 punch for shells.
2 ditto vent.
2 common spikes.
1 spring ditto.
2 thumb stalls.
1 tangent screw.

3 lbs. slow match.

Camp Kettle. Camp Kettle.

HOW.

2 Carbines *strapped in front,* and Blankets, Blanket Covers, and 2 Corn Sacks on *the Lids of the Ammunition Boxes.*

FOR THE AMMUNITION WAGGON OF A 12-POUNDER HOWITZER.

Mode of Packing Ammunition and Stores.

Picket Line. Felling Axe. LIMBER. Hand Bill.

Lifting Jack.

Grease Box, containing 3 lbs. Pair Drag Ropes. Swingletree.

NEAR BOX. OFF BOX.

Shovel.

NEAR BOX		MID BOX	OFF BOX	
12 SHRAPNEL, in 2 tiers. 1 blue bag, containing 12 Shrapnel fuzes. 1 blue box, containing 12 Shrapnel fuzes. 1 strap for fuze box. 6 portfires on lid.	6 SHRAPNEL. 18 1¼ lb. CARTRIDGES. 1 cartouch. 18 20 drm. bursters.	MID Box. 1 dr. washer. 1 linchpin. 2 couples.	2 COMMON SHELLS. 4 CASE SHOT. 18 1¼ lb. CARTRIDGES. 1 cartouch. 14 6 oz. bursters.	12 COM. SHELLS in 2 tiers. 2 black boxes, each containing 8 common fuzes. 50 brass tubes and 50 friction tubes in zinc cylinders. 1 tube pocket with strap.

Spade.

Water Bucket. Pick Axe. Water Bucket.

Drag Shoe. PERCH.

Spare Wheel. (*on Perch*).

FORE BOX.

2 Tents, with Pole Pins, and Bags complete, and 2 Picket Posts.

Box, cont. 10 Sets of Horse Shoes and proportion of Nails.

16 SHRAPNEL, in 2 tiers. 8 1¼ lb. CARTRIDGES. 1 cartouch. 3 blue bags, each containing 12 Shrapnel fuzes.	28 1¼ lb. CARTRIDGES. 1 cartouch. 32 20 drm. bursters.	16 SHRAPNEL, in 2 tiers. slow match. 6 lbs.

2 Tents with Pole Pins, and Bags complete, and 2 Picket Posts.

Box, cont. 10 Sets of Horse Shoes and proportion of Nails.

HIND BOX.—4 Reaping Hooks between the Boxes.

Hand Saw, in Leather Case.

16 COM. SHELLS, in 2 tiers. 100 empty flannel cartridges. 2 black bags, each containing 16 com. fuzes.	28 1¼ lb. CARTRIDGES. 1 cartouch. 28 6 oz. bursters.	4 COM. SHELLS. 4 CARCASSES (below). 8 COM. SHELLS (above). 1 skein Hambro' line. 1 ditto marline.

2 Grease-mag., each cont. 14 lbs. Box, cont. 10 sets Horse Shoes, and pro. of Nails.

Camp Kettle. Maul. Camp Kettle.

The first line of Waggons *only* carries Spare Wheels, Hand Saws, and Reaping Hooks.

4 Spare Splinter Bars, 2 Perches, and 4 pairs of Shafts, per Battery, are distributed among the Waggons, and lashed under them for transport.

2 Carbines strapped in front, and Blankets, Blanket Covers, and 2 Corn Sacks strapped on the Lids of the Ammunition Boxes.

FOR A 9-POUNDER GUN.

Mode of Packing Ammunition and Stores belonging to the Gun, Carriage, and Limber.

Felling Axe.
Grease Box, cont. 3 lbs.
NEAR BOX.

4 CASE SHOT. 1 knife. 1 funnel. 1 blue box, containing 8 Shrap. fuzes. 1 mallet. 2 needles. 1 extractor. 1 scissors. 1 setter. 2 oz. worsted. 1 set fuze borers and bits. 1 strap for fuze box. 1 drift. 1 box for wads and plugs.* 5 fuze sections. 5 copies of Instructions for fixing fuzes. 2 ditto for shells. 1 driver. 2 keys.	6 ROUND SHOT. 8 2½ lb. CARTRIDGES. 6 portfires on lid. 1 cartouch.
	6 SHRAPNEL. 8 2½ lb. CARTRIDGES. 6 15 drm. bursters. 1 cartouch.

Water Bucket.

LIMBER.
Pair Drag Ropes.

Prolonge.

MID BOX.

1 drag washer. 1 linchpin. 2 couples.
1 rammer head.

Hand Bill.
Swingletree.
OFF BOX.

6 ROUND SHOT. 8 2½ lb. CARTRIDGES. 1 cartouch.	4 CASE SHOT. 1 tube pocket with strap. 100 friction tubes in zinc cylinder. 3 lanyards.
6 ROUND SHOT. 8 2½ lb. CARTRIDGES. 1 cartouch.	

Spade.

Pick Axe. Water Bucket.

TRAIL.

* Plugs. { Fuze Hole— 3. Loading Hole— 3.
Wads, Loading Hole— 30.

NEAR, OR RIGHT AXLETREE BOX.

1 set priming irons.
1 sponge head.

Camp Kettle.

Drag Shoe. Sponge. 2 Portfire Sticks. Handspike. Spare Sponge and Handspike and Wadhook underneath the Trail.

Pincers. Spanner. Claw Hammer.

GUN.

OFF, OR LEFT AXLETREE BOX.

Punches { vent 2, shell 1. 2 com. spikes. 1 spring ditto. 2 thumb stalls. 2 spare tangent screw.	3 lbs. Slow Match.

Camp Kettle.

2 Carbines *strapped in front, and* Blankets, Blanket Covers, and 2 Corn Sacks on the *Lids of the* Ammunition Boxes.

FOR THE AMMUNITION WAGGON OF A 9-POUNDER GUN.

Mode of Packing Ammunition and Stores.

LIMBER.

Near Box: Picket Line. Felling Axe. Grease Box, cont. 3 lbs. Shovel. Water Bucket.

Mid Box: Pair Drag Ropes.

Off Box: Lifting Jack. Hand Bill. Swingletree. Spade. Pick Axe. Water Bucket.

NEAR BOX		MID BOX	OFF BOX	
4 COMMON CASE. 50 empty flannel cartridges. 1 blue box, containing 8 Shrapnel fuzes. 1 strap for fuze box.	6 ROUND SHOT. 8 2½ lb. CARTRIDGES. 6 portfires on lid. 1 cartouch. 6 SHRAPNEL. 8 2½ lb. CARTRIDGES. 6 15 drm. bursters. 1 cartouch.	1 dr. washer. 1 linchpin. 2 couples.	6 ROUND SHOT. 8 2½ lb. CARTRIDGES. 1 cartouch. 6 SOLID SHOT. 8 2½ lb. CARTRIDGES. 1 cartouch.	4 COMMON CASE. 1 tube pocket with strap. 50 friction tubes in zinc cylinder. 50 brass tubes in zinc cylinder.

Drag Shoe. PERCH. Spare Wheel, (*on Perch.*)

BODY.

FORE BOX.

Left side: 2 Tents, with Poles, Pins, and Bags complete, and 2 Picket Posts. Box con. 10 sets of Horse Shoes and proportion of Nails.

16 ROUND SHOT. 8 2½ lb. CARTRIDGES. 1 cartouch.	8 SHRAPNEL. 14 2½ lb. CARTRIDGES. 8 15 drm. bursters. 1 cartouch. Blue bag, cont. 8 Shrapnel fuzes.	8 ROUND SHOT. 14 2½ lb. CARTRIDGES. 1 cartouch.

Right side: Box con. 10 sets of Horse Shoes and proportion of Nails. 2 Tents, with Poles, Pins, and Bags complete, and 2 Picket Posts.

HIND BOX.

4 Reaping Hooks between the Boxes.

Left side: Hand Saw, in Leather Case.

8 ROUND SHOT. 14 2½ lb. CARTRIDGES. 1 cartouch. 6 lbs. - - -	8 ROUND SHOT. 14 2½ lb. CARTRIDGES. 1 cartouch. - - - Slow - - -	16 ROUND SHOT, in two tiers. 50 empty flannel cartridges. 1 skein marline. 1 ditto Hambro' line. - - - match.

2 Grease-mag., each cont. 14 lbs. Box, cont. 10 sets Horse Shoes and pro. of Nails.
Camp Kettle. Maul. Camp Kettle.

The first line of waggons *only* carries Spare Wheels, Hand Saws, and Reaping-hooks.

4 Spare Splinter Bars, 2 Perches, and 4 pairs of Shafts, per Battery, are distributed among the Waggons, and lashed under them for transport.

2 Carbines strapped in front, and Blankets, Blanket Covers, and 2 Corn Sacks strapped on the Lids of the Ammunition Boxes.

FOR A 24-POUNDER HOWITZER.

ode of Packing Ammunition and Stores belonging to the Howitzer, Carriage, and Limber.

Felling Axe.
Grease Box, cont. 3 lbs.
NEAR BOX.

LIMBER.
Pair Drag Ropes.

Hand Bill.
Swingletree.
OFF BOX.

Near Box:

12 2¼lb. CARTRIDGES; 12 30 drm. bursters; 1 cartouch; 2 funnels; 1 blue box and ¼ blue bags, each containing 8 Shrapnel fuzes; 1 knife; 1 mallet; 2 needles; 1 extractor; 1 pair scissors; 1 setter; 2 ozs. worsted; 1 set fuze borers and bits; 1 strap for fuze box.

5 copies of Instructions for fixing fuzes; 2 ditto shells; 5 fuze sections; 1 driver; 2 keys; 2 drifts; 1 box for wads and plugs.*

12 SHRAPNELL, in 2 tiers.

6 portfires, on lid.

Water Bucket.

Mid Box:

Prolonge.

MID Box.

1 drag washer.
1 linchpin.
2 couples.

Off Box:

12 2½lb. CARTRIDGES;

1 black box, containing 10 common fuzes;

3 lanyards; 1 tube pocket, with strap;

100 friction tubes, in zinc cylinder;

1 cartouch; 8 13 oz. bursters;

1 box for wads and plugs.†

4 COMMON SHELLS } lower tier.
2 COMMON CASE - }

4 COMMON SHELLS } upper tier.
2 COMMON CASE - }

Spade.

Pick Axe. Water Bucket.

		*	†
[P]lugs	Fuze hole: common	—	7
	Fuze hole: diaphragm Shrapnel	9	—
	Loading hole, diaphragm Shrapnel	9	—
[W]ads	Fuze hole, common	—	75
	Loading hole, diaphragm Shrapnel	96	—

TRAIL.

2 Portfire Sticks. Handspike.
Spare Sponge and Handspike and Wadhook underneath the Trail.

NEAR, OR RIGHT AXLETREE BOX.

1 set priming irons.

1 sponge head.

1 rammer head.

Camp Kettle.

Drag Shoe. Sponge.

Pincers. Spanner. Claw Hammer.

OFF, OR LEFT AXLETREE BOX.

2 vent and 1 shell punches.
2 common spikes.
1 spring do.
2 thumb stalls.
1 spare tan. screw.

3 lbs. slow match.

Camp Kettle.

HOWITZER.

2 Carbines strapped in front, and Blankets, Blanket Covers, and Corn Sacks on the Lids of the Ammunition Boxes.

FOR THE AMMUNITION WAGGON OF A 24-POUNDER HOWITZER.

Mode of Packing Ammunition and Stores.

Picket Line. Felling Axe. LIMBER. Lifting Jack. Hand Bill.
Grease Box, cont. 3 lbs. Pair Drag Ropes. Swingletree.

Shovel.

NEAR BOX.	MID BOX.	OFF BOX.
12 2½ lb. CARTRIDGES. 1 cartouch. 12 30 drm. bursters. 1 blue box and 1 blue bag, each containing 8 Shrapnel fuzes. 1 strap for fuze box.	1 drag washer. 1 linchpin. 2 couples.	12 2½ lb. CARTRIDGES. 8 13 oz. bursters. 1 cartouch. 1 black box, containing 10 common fuzes. 1 tube pocket with strap. 50 brass and 50 friction tubes in zinc cylinders.
12 SHRAPNEL, in 2 tiers. 6 portfires on lid.		4 COMMON SHELLS, 2 COMMON CASE } lower tier. 4 COMMON SHELLS, 2 COMMON CASE } upper tier.

Spade.

Water Bucket. Pick Axe. Water Bucket.

Drag Shoe. PERCH.
Spare Wheel.
(*on Perch.*)

BODY.

2 Tents, with Poles, Pins, and Bags complete, and 2 Picket Posts.
Box, containing 10 sets of Horse Shoes and proportion of Nails.
Hand Saw in leather case.

FORE BOX.	
18 2½ lb. CARTRIDGES. 18 30 drm. bursters. 1 cartouch. 2 blue bags, each containing 8 Shrapnel fuzes.	18 SHRAPNEL, in 2 tiers. 6 lb. slow match.

HIND BOX.—4 Reaping Hooks between the Boxes.

HIND BOX.	
7 COMMON SHELLS, 2 CARCASSES } lower tier. 9 COMMON SHELLS, upper tier. 1 skein Marline. 1 skein Hambro' line. 50 empty flannel cartridges. 2 black bags, each containing 10 common fuzes.	18 2½ lb. CARTRIDGES. 16 13 oz. bursters. 1 cartouch.

2 Tents, with Poles, Pins, and Bags complete, and 2 Picket Posts.
Box, containing 10 sets of Horse Shoes and proportion of Nails.

2 Grease Magazines, each containing 14 lbs. Box, containing 10 sets of Horse Shoes, and proportion of Nails.

Camp Kettle. Maul. Camp Kettle.

The first line of Waggons *only* carries Spare Wheels, Hand Saws, and Reaping Hooks.

4 Spare Splinter Bars, 2 Perches, and 4 pairs of Shafts, per Battery, are distributed among the Waggons, and lashed under them for transport.

2 Carbines strapped in front, and Blanket Covers, and 2 Corn Sacks strapped on the Lids of the Ammunition Boxes.

FOR A 12-POUNDER GUN.

de of Packing the Ammunition and Stores belonging to the Gun, Carriage, and Limber.

Felling Axe.
cont. 3 lbs.
EAR BOX.

). CARTRIDGES.
: cartouch.
›rtfires on lid.

ɪHOT; 2 needles;
t; 2 ozs. worsted;
; 1 setter; 1 blue
ıtaining 12 Shrap.
1 scissors; 1 strap
ɘ box; 1 set fuze
.nd bits; 1 funnel;
ıctor; 2 keys; 1
5 fuze sections;
s Instructions for
2 ditto for shells;
; 1 box of wads
gs.*

D SHOT, in 2 tiers.

'ater Bucket.

LIMBER.
Pair Drag Ropes.

Prolonge.

MID BOX.

6 SHRAPNEL.
6 4 lb. CARTRIDGES.
6 20 drm. bursters.
1 cartouch.

Hand Bill.
Swingletree.
OFF BOX.

9 4 lb. CARTIDGES.
1 cartouch.

Spade.

3 CASE SHOT; 1 tube pocket with strap; 100 friction tubes in zinc cylinder; 3 lanyards.

6 ROUND SHOT, in 2 tiers.

Pick Axe. Water Bucket.

ıze Hole - - 5
›ading Hole- 5
ıg Hole - - 50

TRAIL.

Drag Shoe.
Elevat. Screw.
Sponge.
2 Portfire Sticks. Handspike.
1 Shifting Roller.
Spare Sponge and Handspike and Wadhook underneath the Trail.

Pincers.
Spanner.
Claw Hammer.

GUN.

OFF, OR LEFT AXLETREE BOX.

1 pun. for shell; 2 for vents; 2 couples; 2 com. spikes; 1 spring do.; 2 th. stalls; 1 set pr. irons; 1 drag washer; spare tan. screw and linchpin.

3 lbs. slow match.

Kettle.

Camp Kettle.

ɪes strapped in front, and Blankets, Blanket Covers, and 2 Corn Sacks *on the Lids of the* Ammunition Boxes.

FOR THE AMMUNITION WAGGON OF A 12-POUNDER GUN.

Mode of Packing the Ammunition and Stores.

Picket Line. Felling Axe. LIMBER. Lifting Jack. Hand Bill.
Grease Box, cont. 3 lbs. Pair Drag Ropes. Swingletree.

NEAR BOX.

Shovel.

4 SHRAPNEL (below). 1 skein of Marline. 1 do. Hambro' line. 1 blue box, containing 12 Shrapnel fuzes. 1 strap fuze box.	8 4 lb. CARTRIDGES. 1 cartouch. 6 ROUND SHOT (below). / 6 Shrapnel. 8 4 lb. CARTRIDGES. 10 20 drm. bursters. 1 cartouch. 5 portfires on lid.

1 linchpin. 1 washer. 2 couples.

OFF BOX.

8 4 lb. CARTRIDGES. 1 cartouch. 6 ROUND SHOT. / 8 4 lb. CARTRIDGES. 1 cartouch. 6 ROUND SHOT.	1 tube pocket, with strap. 50 brass tubes in zinc cylinder. 4 CASE SHOT. 50 friction tubes in zinc cylinder.

Spade.

Water Bucket. Pick Axe. Water Bucket.

Drag Shoe. PERCH.

Spare Wheel (on Perch).

FORE BOX.

2 Tents, with Poles, Pins, and Bags complete, and 2 Picket Posts. Box, cont. 10 sets of Horse Shoes and proportion of Nails.

4 ROUND SHOT (below). 4 SHRAPNEL (above). 50 empty flannel cartridges. A blue bag containing 12 Shrapnel fuzes.	12 4 lb. CARTRIDGES. 12 20 drm. bursters. 1 cartouch. 8 SHRAPNEL.	12 4 lb. CARTRIDGES. 1 cartouch. 8 ROUND SHOT.

2 Tents, with Poles, Pins, and Bags complete, and 2 Picket Posts. Box, cont. 10 sets of Horse Shoes and proportion of Nails.

HIND BOX.
4 Reaping Hooks between the Boxes.

Hand Saw in leather case.

12 4 lb. CARTRIDGES. 1 cartouch. 8 ROUND SHOT (below).	12 4 lb. CARTRIDGES. 1 cartouch. 8 ROUND SHOT (below).	Spare sponge head. Do. rammer. 6 lbs. slow match. 8 SOLID SHOT, in 2 tiers.

2 Grease Mags., each cont. 14 lbs. Box, cont. 10 sets of Horse Shoes and pro. of Nails
Camp Kettle. Maul. Camp Kettle.

The first line of Waggons only carries Spare Wheels, Hand Saws, and Reaping Hooks.
4 Spare Splinter Bars, 2 Perches, and 4 pairs of Shafts, per Battery, are distributed among the Waggons, and lashed under them for transport.
2 Carbines strapped in front, and Blankets, Blanket Covers, and 2 Corn Sacks strapped on the Lids of the Ammunition Boxes.

FOR A 32-POUNDER HOWITZER.

Mode of Packing Ammunition and Stores belonging to the Howitzer, Carriage, and Limber.

LIMBER.

Felling Axe. Grease Box, cont. 3 lbs. NEAR BOX.	Pair Drag Ropes. Prolonge. MID BOX.	Hand Bill. Swingletree OFF BOX.
2 SHRAPNEL. 2 40 drm. bursters. 2 3 lb. CARTRIDGES. 1 cartouch.	2 COMMON CASE. 2 3 lb. CARTRIDGES. 1 cartouch.	2 COMMON SHELLS. 2 3 lb. CARTRIDGES. 2 18 oz. bursters. 1 cartouch.
4 SHRAPNEL. 4 3 lb. CARTRIDGES. 4 40 drm. bursters. 1 cartouch. 5 portfires on lid.	* 50 friction tubes in zinc cylinder. 3 lanyards. 1 black box, containing 10 common fuzes.	4 COMMON SHELLS. 4 3 lb. CARTRIDGES. 4 18 oz. bursters. 1 cartouch.
Water Bucket.		Pick Axe. Water Bucket.

Spade.

* This Box should contain, in addition, the following Stores:—

1 blue box, containing 12 Shrap. fuzes; knife; 1 mallet; 2 funnels; 2 needles; extractor; 1 scissors; 1 setter; 2 oz. of worsted; set fuze borers and bits; 1 strap for fuze box; 5 copies of Instructions for fixing fuzes; 2 do. for shells; 5 fuze sections; driver; tube pocket with strap; 2 keys; 2 drifts; 2 boxes for wads and plugs.

TRAIL.

2 Portfire Sticks. Handspike.
1 Shifting Roller.
Spare Sponge and Handspike and Wadhook underneath Trail.

		1st Box.	2nd Box.
†Plugs, fuze hole	common	—	8
	diaphragm Shrapnel	—	6
Wads	loading-hole, diaphrm. Shrapnel	—	6
	fuze hole, common	90	—
	loading-hole, diaphrm. Shrapnel	—	68

NEAR, OR RIGHT AXLE-TREE BOX.

2 couples.
1 drag washer.
1 linchpin.
1 sponge head.
1 rammer head.
1 set priming irons.

Camp Kettle.

Drag Shoe.

Sponge.

Pincers. Spanner.

Claw Hammer.

OFF, OR LEFT AXLE-TREE BOX.

3 lbs. slow match.

1 punch for shells.
2 punches for vents.
1 spare tangent screw.
2 common spikes.
1 spring ditto.
2 thumb stalls.

Camp Kettle.

HOWITZER.

2 Carbines *strapped in front, and Blankets,* Blanket Covers, and 2 Corn Sacks on the *Lids of the Ammunition Boxes.*

FOR THE AMMUNITION WAGGON OF A 32-POUNDER HOWITZER.

Mode of Packing the Ammunition and Stores.

Picket Line. Felling Axe. LIMBER. Lifting Jack. Hand Bill.
Grease box, containing 3 lbs. Pair Drag Ropes. Swingletree.

NEAR BOX. OFF BOX.

Shovel.

1 skein of marline. Do. Hambro' line. 6 SHRAPNEL, in 2 tiers.	12 3lb. CARTRIDGES. 10 40drm. bursters. 1 cartouch.	Blue box, containing 12 Shrapnel fuzes. 1 fuze box strap. 4 SHRAPNEL, in 2 tiers. 2 common case.	Black box, containing 10 common fuzes. 6 COMMON SHELLS, in 2 tiers.	12 3lb. CARTRIDGES. 12 18oz. bursters. 1 cartouch.	Tube pocket with strap. 50 friction tubes and 25 brass tubes in zinc cylinders. 6 COMMON SHELLS, in 2 tiers.
6 portfires - - on - - - - lid.					

Spade.

Bucket. Pick Axe. Water Bucket.

Drag Shoe. PERCH

Spare Wheel. on (Perch).

BODY.

FORE BOX.

2 Tents, with Poles, Pins, and Bags complete, and 2 Picket Posts.

Box, containing 10 sets of Horse-shoes and proportion of Nails.

1 blue bag, containing 12 Shrapnel fuzes. 6 SHRAPNEL, in 2 tiers.	9 3lb. CARTRIDGES. 1 cartouch. 6 SHRAPNEL. 12 40drm. bursters. 50 empty flannel cartridges.	6 3lb. CARTRIDGES. 1 cartouch. 3 18oz. bursters. 3 COMMON SHELLS.

Box, containing 10 sets of Horse-shoes and proportion of Nails.

2 Tents, with Poles, Pins, and Bags complete and 2 Picket Posts.

HIND BOX.

4 Reaping Hooks between the Boxes.

Hand Saw in Leather Case.

6 3lb. CARTRIDGES. 1 cartouch. 3 18oz. bursters. 3 COMMON SHELLS.	9 3lb. CARTRIDGES. 1 cartouch. 10 18oz. bursters. 6 COMMON SHELLS.	2 black bags, each containing 10 common fuzes. 4 COMMON SHELLS, and 2 carcasses, in 2 tiers. 1 linchpin. 2 couples. Drag washer.
6 lbs. - -	- - slow - -	- - match.

2 Grease Mags., each containing 14 lbs. Box, containing 10 sets of Horse-shoes and proportion of Nails.

Camp Kettle. Maul. Camp Kettle.

The first line of Waggons only carries Spare Wheels, Hand Saws, and Reaping Hooks.

4 spare Splinter Bars, 2 Perches, and 4 pairs of Shafts, per Battery, are distributed among the Waggons, and lashed under them for transport.

2 Carbines strapped in front, and Blankets, Blanket Covers, and 2 Corn Sacks strapped on the Lids of the Ammunition Boxes.

FOR AN 18-POUNDER GUN, ON BLOCK TRAIL CARRIAGE.

Mode of Packing the Ammunition and Stores belonging to the Gun, Carriage, and Limber.

LIMBER.

Pair Drag Ropes.

Grease Box, cont. 3 lbs. Felling Axe. Barrel Jack. Hand Bill. Swingletree.

Shovel. (near side) — **Spade.** (off side)

NEAR BOX.

3 round shot. 3 grape shot. 1 black box, cont. 8 common fuzes. 1 box for wads and plugs, cont. 4 fuze hole plugs and 46 do. wads. 100 friction tubes in zinc cylinder. 1 drift. 1 fuze extractor. 2 needles. 2 oz. worsted. 2 keys for shells. 1 tube pocket with strap. 3 lanyards. 5 fuze sections. 5 Instructions for fixing fuzes. 2 ditto for shells. 1 funnel, 1 driver. 1 strap, fuze box.	6 common shells. 12 6 lb. cartridges. 6 10 oz. bursters. 1 cartouch.

MID. BOX.

4 couples.
1 linchpin, 13-pr.
3 Drag washers { 1 18-pr. 2 9-pr.

OFF BOX.

6 round shot. 12 6 lb. cartridges. 1 cartouch.	3 round shot. 3 case shot. 1 mallet. 1 setter. 1 wood tangent scale. 1 fore sight. 1 hind sight. 5 fixing screws. 1 sight wrench. 1 set of fuze borers and bits. 1 set of priming irons. 1 scissors. 2 thumbstalls. 1 knife. 2 punches for vent. 2 common spikes. 1 spring spike. 1 punch for shells.

Water Bucket. Pick Axe. **Water Bucket.**

GUN.

Drag Shoe.
1 Sponge, Elevating Screw, Handle for Screw.
Claw Hammer.
4 Handspikes. Portfire Sticks.
Wad Hook, 1 spare Rammer, 18 ft. lever, and 1 Sponge, underneath the Trail.
Pincers. Spanner.
Shifting Roller.

FOR THE AMMUNITION WAGGON OF AN 18-POUNDER GUN.

Mode of Packing the Ammunition and Stores.

LIMBER.

1 Picket Line.

Grease Box, cont. 3 lbs. Felling Axe. Lifting Jack. Hand Bill. Swingletree.

	NEAR BOX.			OFF BOX.		
Shovel.	3 round shot. 3 grape shot. 1 fuze box, containing 8 common fuzes. 1 fuze box strap. 50 friction tubes and 10 brass tubes in zinc cylinders. 1 tube pocket and strap.	6 common shells. 12 6 lb. cartridges. 6 10 oz. bursters. 1 cartouch. 4 portfires on lid.	1 pair of Heavy Drag Ropes. MID BOX. 1 linchpin, 9-pr. 4 couples for traces.	6 round shot. 12 6 lb. cartridges. 1 cartouch.	3 round shot. 3 case shot. 1 skein of marline. 1 skein of Hambro' line.	Spade.

Water Bucket. Pick Axe. Water Bucket.

Drag Shoe. PERCH.

Spare Wheel (on Perch).

BODY.

	FORE BOX.			
Box, cont. 10 sets of Horse-shoes and proportion of Nails.	6 round shot in 2 tiers. 1 black bag, containing 8 common fuzes. 4 lbs. slow match.	4 portfires 6 common shells. 9 6 lb. cartridges. 6 10 oz. bursters. 1 cartouch.	on lid. 6 round shot. 9 6 lb. cartridges. 1 cartouch.	2 Picket Posts. Box, cont. 10 sets of Horse-shoes and proportion of Nails.

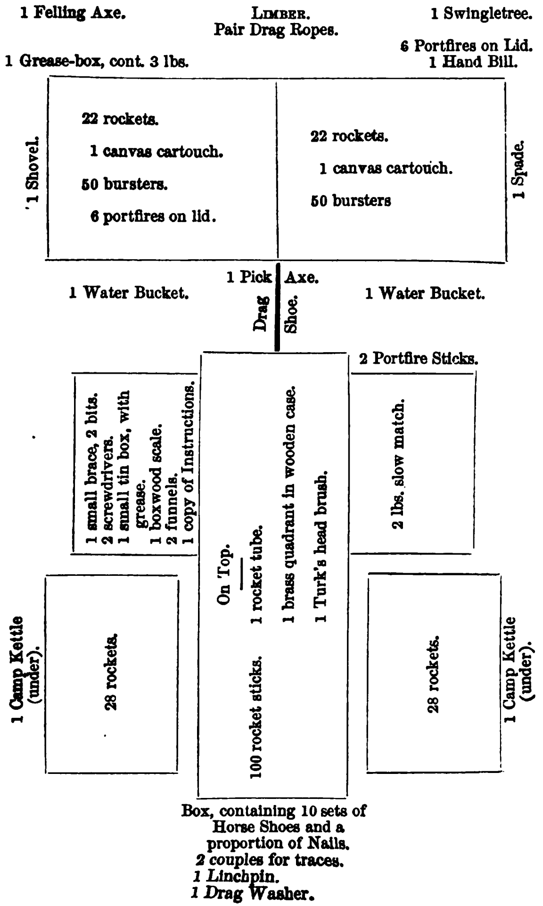
	HIND BOX.		
2 Picket Posts. Hand Saw in Leather Case.	6 round shot. 9 6 lb. cartridges. 1 cartouch.	6 round shot. 9 6 lb. cartridges. 1 cartouch.	6 round shot in 2 tiers. 1 rammer head. 1 sponge head. 10 empty flannel cartridges.

2 Grease Mags., each cont. 14 lbs. Camp Kettle. Maul. Camp Kettle.

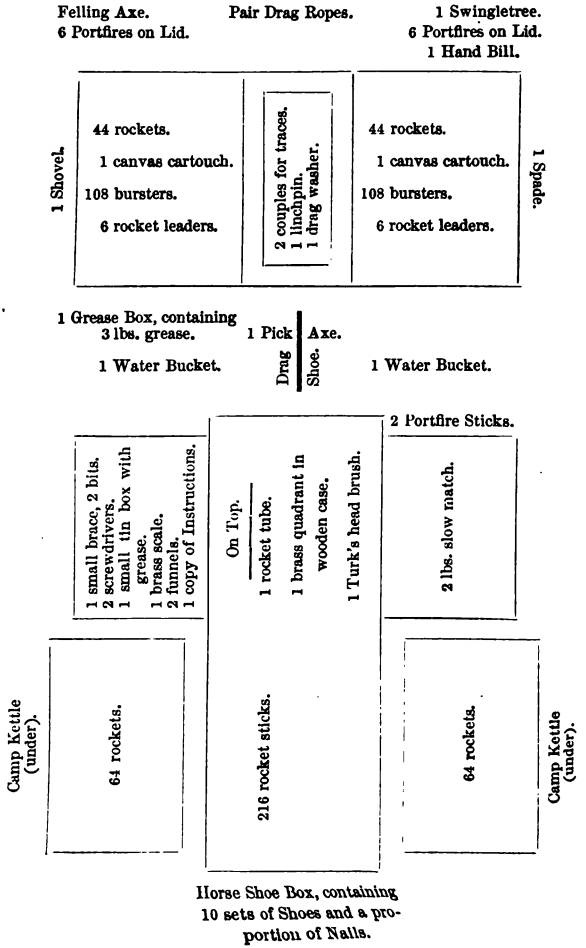
2 spare Splinter Bars, 1 spare Perch, and 1 pair of Single Shafts per Battery, are *distributed* among the Waggons, and lashed under them for transport.

12-POUNDER ROCKET CARRIAGE.

Mode of Packing.



6-POUNDER ROCKET CARRIAGE.



SMALL ARM AMMUNITION WAGGON.

Mode of Packing the Ammunition and Stores.

Limber.

1 Lifting Jack.
1 Picket Rope.
1 Pair of Drag Ropes.

1 Felling Axe.
1 Grease Box, containing 3 lbs.

1 Swingletree.
1 Hand Bill.

1 Shovel.

12 Ammunition Boxes, each containing 480 rounds of small-arm ammunition, viz.:—

A - B

Cartridges, ball, 1853 pattern, 2½ drams	5,760
Caps, Percussion - - - - - -	8,640
Boxes, zinc, for ditto - - - -	12

Note.—*If only 8 boxes are carried, the partition A B is required in its place; when not used, it is carried on the top of the ammunition boxes.*

1 Spade.

1 Water Bucket.

Drag Shoe.

1 Pick Axe.
1 Water Bucket.

24 Ammunition Boxes, each containing 480 rounds of small arm ammunition, viz.:—

Cartridges, ball, 1853 pattern, 2½ drams	11,520
Caps, Percussion - - - - - -	17,280
Boxes for ditto, zinc - - - -	24

2 pairs of pack saddle ladders on lid.

2 Grease mags., each containing 14 lbs.

1 Camp Kettle.

Box, containing 10 Sets of Horse Shoes with proportion of Nails.
1 Linchpin.
1 Drag Washer.
2 Couples for Traces.
1 Maul.
1 Camp Kettle.

FOR THE STORE WAGGON OF A

1 Camp Kettle (under).

Box, containing 10 sets of Horse Shoes and a proportion of Nails.

2 Grease Magazines, each containing 14 lbs.

Materials for the use of Artificers.

For Wheelers:—

Bolts, Tire, with collars		67
Cords, Forage, for tent lashings		36
Felloes, ash, rough, of sorts		6
Glue	lbs.	6
Grease	„	84
Nails, Brads, No. 94	„	4
Nails, Clasp, No. 32	„	4
Nails, Clasp, No. 33	„	6
Nails, Clasp, No. 39	„	6
Nails, Clout, chisel pointed, No. 56	„	3
Nails, Clout, chisel pointed, No. 57	„	12
Nails, Clout, chisel pointed, No. 58	„	9
Nails, Clout, chisel pointed, No. 59	„	12
Nails, Clout, chisel pointed, No. 61	„	16
Nails, Clout, chisel pointed, No. 62	„	6
Nails, Clout, chisel pointed, No. 63	„	15
Nails, Tire	„	6
Rings, with starts		12
Spokes, oak, rough		9
Screws, Iron, Looped		12
Screws, Iron, 1¼ inch, No. 207		24
Screws, Iron, 1¼ inch, No. 226		36
Screws, Iron, 1½ „, No. 206		48
Screws, Iron, ¾ „, No. 203		48
Screws, Iron, ¾ „, No. 242		48
Staples, Iron, Lashing		20
Staples, Iron, Round crown, Large		3
Staples, Iron, Round crown, Small		9
Stones, rag		2
Straps, side arm		6
Tires for wheels, streaks		6
Turnbuckles, small		6

For Smiths:—

Hooks, curb	100

For Collar Makers:—

Buckles, Brass, Roller, 1¼ inch		13
Buckles, Brass, Roller, 1 „		12
Buckles, Brass, Roller, ⅞ „		12
Buckles, Brass, Roller, ¾ „		12
Buckles, Brass, Sword Belt		13
Buckles, Iron, Japanned, 1 inch		24
Buckles, Iron, Polished Roller, ½ inch		36
Buckles, Iron, Polished Roller, ⅝ „		24
Buckles, Iron, Polished Roller, ¾ „		36
Buckles, Iron, Polished Roller, ⅞ „		34
Buckles, Iron, Polished Roller, 1 „		72
Buckles, Iron, Polished Roller, 1¼ „		42
Buckles, Iron, Polished Roller, 1½ „		36
Buckles, Iron, Polished Roller, 1¾ „		12
Buckles, Iron, Polished Roller, 2 „		12
Buckles, Iron, Polished Roller, 2¼ „ Backband		12
Buckles, Iron, Polished Roller, 2¼ „ Bellyband		12
Brushes, Harness, hard		8
Basils, Brown		36
Cord, Whip	lbs.	4
Curbs		12
Dubbing	lbs.	14
Duck, Russia	yds.	20
Hames, Iron	pairs	9
Hair, Does	lbs.	28
Hair, Horse	„	28
Hides, Brown, Bridle		1
Hides, Brown, Heavy		2
Hides, Brown, Light		4
Hides, Brown, Saddle Seat		2
Hides, Brown, Trace		3
Hides, Buff		1
Hides, White Horse		1
Lanterns, Tin		2
Nails, Tack, No. 50 lbs.		6
Nails, Tack, „ 51 „		2
Nails, Tack, „ 52 „		2
Nails, Tack, „ 70 „		2
Nails, Tack, „ 71 „		2
Nails, Tack, „ 72 „		2
Nails, Tack, „ 73 „		4
Oil, Lucca	gals.	8
Oil, Sweet	„	10
Pans, Tin Oil		6
Plates, Waist, Sword Belt	pairs	6
Rings, Sword Belt		12
Rings, Snipe Bill		24
Rope, Tarred, ¾ inch	fath.	12
Rope, Traced	„	6
Serge	yds.	20
Skins, Sheep, black		12
Wax, Bees'	lbs.	2
Wax, Black	„	4

1 Camp Kettle (under).

12-POUNDER ARMSTRONG GUN BATTERY.

Mode of Packing the Stores.

LIMBER.

1 Shovel.

1 Felling Axe.

1 Grease Box, containing 3 lbs.

1 Chest of Collar Maker's Tools.

1 Swingletree.

1 Hand Bill.

1 Linchpin.

1 Washer.

2 Couples for Traces.

Remaining part of set of Iron-work, consisting of

(First portion in Spare Gun Carriage).

Trunnion Plates	2
Capsquares	2
Bands for Axletree bed . .	2
Saddle Metal	1
Traversing Screw for ditto .	1
Lever, iron, for ditto . . .	1
Plate for turning in Fuzes .	1
Screwdriver	1
Keys for Capsquares . . .	4
Socket Metal for spare Vent .	1
Bolts of sorts	12

Spring Locks, with keys (in case)	6
Collar Maker's Tools packed in Trays, sets	2
Coppers, Breech	4
Rings for Ventpiece . . .	4

1 Spade.

1 Water Bucket.

1 Pick Axe.

1 Water Bucket.

Drag Shoe.

1 Wheeler's Sampson.

Box, containing 10 sets of Horse Shoes and a proportion of Nails.

Box, containing 10 sets of Horse Shoes and a proportion of Nails.

Thread	Black	lbs.	1
	Collar	,,	6
	Hemp	,,	12
	Whited Brown . . .	,,	1
Web . .	Diaper 2 inches . . .	yards	20
	Girth 3½ ,, . . .	,,	20
	Girth 4 ,, . . .	,,	20
Whips, spare			6

FOR THE SPARE GUN CARRIAGE OF A 12-POUNDER ARMSTRONG GUN BATTERY.

Mode of Packing the Stores belonging to the Carriage and Limber.

1 Felling Axe. LIMBER. 1 Swingletree.

1 Grease Box, containing 3 lbs. 1 Hand Bill.

1 Shovel.

Part of set of iron work, consisting of (*Remainder in Store Waggon*)	
Trail eye for carriage, complete	1
Nose plate for ammunition waggon	1
Limber hook	1
Skid chains	2
" hooks	3
Advance chains	2
Yoke hoops	2
Jack plates { carriage	2
Jack plates { waggon, or limber	2
Locking plates	2
Camp kettle plates	2
Drift pins	2
Handles, iron, for trail, complete	2
Portfire, socket	1
Lanyard hook	1
Handspike stop	1
Advance chain hook	1
Sponge iron	1
Handspike iron	1
Bolts for carriage (screwed)	11
Rivets for ditto	4
Nut-headed screws	2
Screws, elevating	2
Flange for ditto	1
Straps, of sorts	12
Bag, with screws and staples, of sorts	1
Knock-up wrench	1
Wheeler's tools in trays, sets, complete	1

1 Spade.

1 Pick Axe.

1 Water Bucket. TRAIL. 1 Water Bucket.

1 Axletree (under).
1 Handspike.

1 Handspike.
1 Axletree (under).

1 Drag Shoe.

1 Spare Drag Shoe.

1 Spare Drag Shoe, 1 Sponge Bucket.

2 couples for traces.
1 linchpin.
1 drag washer.

1 Camp Kettle.

1 Camp Kettle.

FOR THE FORGE WAGGON OF A 12-POUNDER ARMSTRONG GUN BATTERY.

Mode of Packing the Stores.

1 Felling Axe. LIMBER. 1 Swingletree.
1 Grease Box, cont. 3 lbs. 1 Hand Bill.

1 Shovel.

Veterinary surgeon's implements	1
Smith's tools, set	1
Tools, special set	1
Facing implements, set	1
Stocks and dies, set	1
Cloths, emery, sheets	18
Emery, fine, lbs.	2
Coppers, breech	6
Rings, copper, vent-piece	6
Bouches, vents, sets	2

1 Spade.

1 Pick Axe.

1 Water Bucket.

Box, cont. 10 sets of Horse Shoes and a proportion of Nails.

1 Water Bucket.

			lbs.
Iron	Bolt $\frac{5}{8}$ inch		28
	Flat	$1\frac{1}{2} \times \frac{1}{2}$	28
		$1 \times \frac{1}{2}$	28
	Square	1 inch	56
		$\frac{5}{8}$,,	28
Steel blister, flat $2 \times \frac{1}{2}$			10

Vice.
Linchpin.
Washer.
2 couples for traces.

Farrier's chest (on top).

Anvil block.

Anvil.

1 Camp Kettle (under).

Coals.

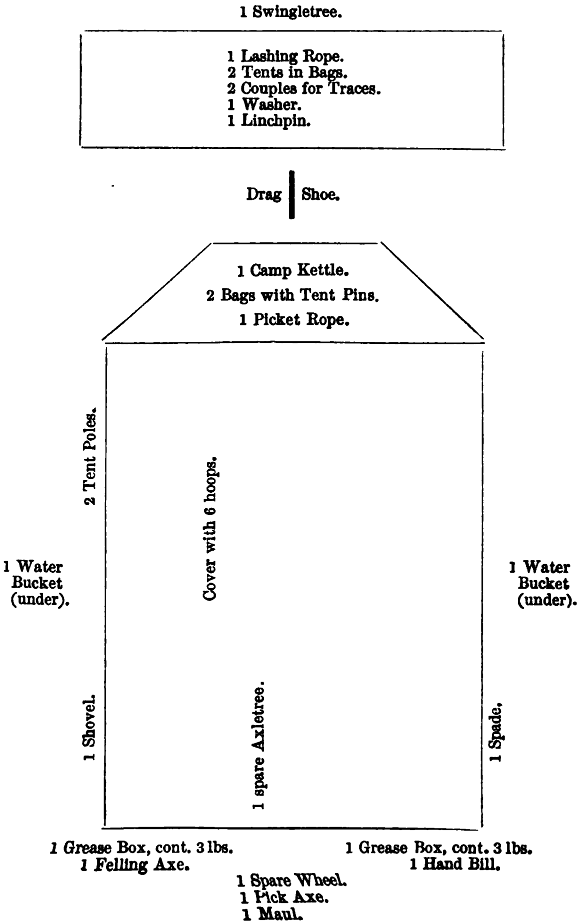
Coals.

Iron Hoop, 1¼ inch, 28 lbs. (*under the side*).

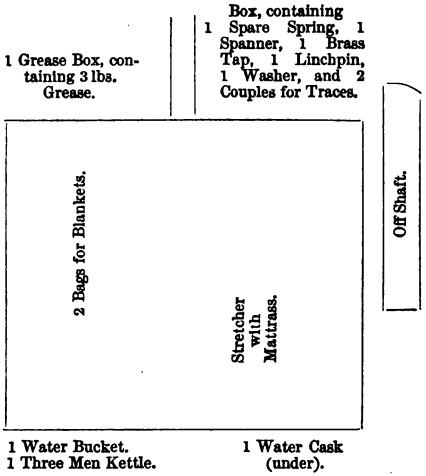
1 Camp Kettle (under).

Bellows.

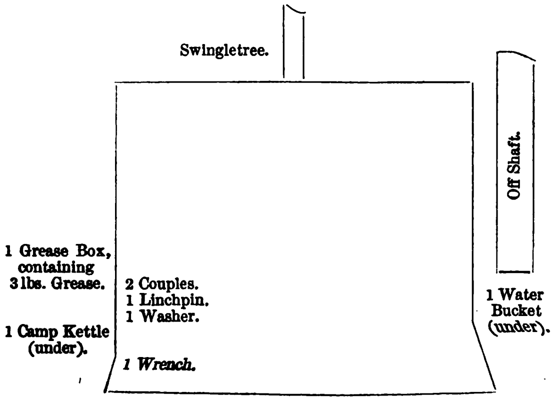
FORAGE WAGGON.



MEDICINE CART.



STORE CART.



PART VI.

ARMSTRONG GUNS.

LAND SERVICE.

EXTRACTED FROM "OBSERVATIONS ON THE GUNS, CARRIAGES, AND AMMUNITION; WITH INSTRUCTIONS FOR THEIR CARE AND USE."

CHAPTER I.—EXPLANATORY OBSERVATIONS UPON THE ARMSTRONG BREECH-LOADING GUNS FOR LAND SERVICE.

1. The different parts of the Guns, Weights, &c.

	110-pounder.			40-pounder.			20-pounder.			12-pounder.			9-pounder.			6-pounder.		
	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.
Average Weight of Barrel	74	1	26	29	3		14	2	8	7	2	24¼	5	1	21	2	2	1½
Breech Screw . . .	3	3	9	1	1	9		2	23½		1	10¾		2	5			23½
Elevating Eye . . .									7½			3¾						1
Lever and Pins . . .	1	1	5		2	18			23½			18¼						11
Saddles, Screws, and Sights		2	19												1½			
Tappet Ring and Pins .		2	1			20			12½			9						4½
Tangent Ring and Sights						22			16			8						7½
Vent-piece	1	0	24		1	15			21			10			14½			7
Total Nominal Weight	82			32	2		16			8	2		6	0	14	3		
Calibre	7″			4·75″			3·75″			3″			3″			2·5″		
Length	120″			120″			96″			84·125″			62″			60·15″		
Number of Grooves	76			56			44			38			38			32		
Twist of Rifling .	1 in 37 Calibres.			1 in 36½ Calibres.			1 in 38 Calibres.			1 in 38 Calibres.			1 in 38 Calibres.			1 in 30 Calibres.		

2. A gun "complete" consists of—

	110-Pr.	40-Pr.	20-Pr.	12-Pr.	9-Pr.	6-Pr.
Barrel	1	1	1	1	1	1
Breech Screw	1	1	1	1	1	1
Tappet Ring	1	1	1	1	1	1
Lever	1	1	1	1	1	1
Keep Pins	2	2	4	4	4	4
Vent-piece	1	1	1	1	1	1
Saddle, with Tightening Screws	1					
Breech Tangent Rings		1	1	1		1
Tangent Sights	2	1	1	1	1	1
Trunnion Sights	2	1	1	1	1	1
Ratchet Sight			1	1		
Point Blank Sight						1
Dispart Sight			1	1		1
Elevating Eye and Bolt, with Pin			1	1		1
Plug for Oil-hole			1	1		1
Drip Plate, and Screws				1		

DESCRIPTION OF THE ARMSTRONG GUN AND FITTINGS, WITH EXPLANATORY REMARKS ON THE USE, AND WORKING OF THE DIFFERENT PARTS.

3. *Gun.*—The gun consists of the barrel, the breech piece, the trunnion piece, and the coils.

4. *Barrel.*—The barrel contains the bore, the powder and bullet chambers. The bullet chamber and bore are rifled. The powder chamber is not rifled, but is of a larger diameter than the bullet chamber; and the latter is again larger than the bore.

The barrel is made from wrought-iron bars, of a rectangular section. These bars are wound round a mandril, forming coils, varying from 18 to 30 inches in length; and are afterwards welded together until the required length of barrel is obtained.

The barrel is then bored and turned, ready for the reception of the layers of coils.

5. *Breech piece.*—The breech piece is a cylinder (made from a solid wrought-iron forging) bored, turned, and shrunk upon the end of the barrel. It contains an internal angular thread, in which the breech screw works.

6. *Trunnion, Wrought iron.*—The trunnion piece is made from a solid forging, and after being bored and turned, is shrunk in its place on the gun.

7. *Coils.—The coils are made* according to their respective diameters *and lengths, in a similar* manner to the coils of the barrel; they are

then bored, turned, and shrunk on the barrel, and the other coils, according to the various natures of guns.

CHAPTER III.—EXPLANATORY OBSERVATIONS ON THE AMMUNITION FOR ARMSTRONG GUNS.

42. *Cartridges.*—These are made of serge, and are filled with R. L. G. A^4 powder. The 40-pounders and smaller natures are made up with Boxer's lubricators choked in them, but the 64-pounders are made up with the lubricators separate, in order to economize magazine space as much as possible, paper sockets being fixed in the choke of the cartridges, for the purpose of attaching the lubricators. The quantity of powder in these cartridges is the same for shot and shell.

QUANTITY OF POWDER IN EACH NATURE OF CARTRIDGE.

	7-inch Gun.	40-Pr.	20-Pr.	12-Pr.	9-Pr.	6-Pr.
Service . Shot .	14	5	$2\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{8}$	$\frac{3}{4}$
Service . Shell .	12					
Exercise and Salutes . . .	..	..	..	1	..	..

Lubricator, Boxer's, consists of a disc of milled board, a thick felt ring, and an air-tight vessel of very thin copper, filled with equal proportions of grease and oil.

TUBES.

43. *Friction Tubes, Copper.*—These tubes are used in all natures of Land Service Armstrong guns, as for smooth-bore ordnance.

44. *Primers* are used with the 64-pr. and 40-pr. guns, and are introduced into the horizontal portion of the vent in the vent-piece.

Their service is to carry the fire readily from the friction tubes to the cartridge, the length and form of the vent holes being such that the friction tube alone will not readily ignite the cartridge.

45. *Projectiles.*—These are of three natures, viz., solid shot, common shell, and segment shell.

The Solid Shot are simple iron castings, covered with a lead coating, of diameters suited to the bores of the various natures of guns.

The Common Shell are hollow castings, prepared for the reception of a bursting charge of powder, and are open at the conical end, into which the plug or fuze is screwed. This nature of shell has a lead coating similar in every respect to that of the solid shot; the fuze holes of all common shells are of the General Service gauge.

The Segment Shell consists of thin cast-iron cylinders, enclosing a series of segments of the same metal, cast separately, and built upon an iron disc, and the segments are held together by lead being run into the interstices between the segments. The form of the outer portion of the lead in this shell is the same as that of the solid shot and common shell. A small bursting charge is used with these shells.

46. The fuze holes of the 7-inch for G. S., 64-pr. and 40-pr. shells, as well as the 20-pr. common shells, are of the General Service gauge, and those of the other natures of guns are of a smaller diameter.

The following is a tabular statement of the bursting charge of the shells:—

COMMON SHELL.

Designation.	110-Pr.	40-Pr.	20-Pr.	12-Pr.	9-Pr.	6-Pr.
	lbs.	lbs.	lbs.			
Mean weight of shell . . .	98	38½	20½	..	..	..
Bursting charge .	8	2½	1	..	..	..
Total weight, exclusive of fuze .	106	41	21½	..	..	..

SEGMENT SHELL.

	110-Pr.	40-Pr.		20-Pr.		12-Pr.		9-Pr.		6-Pr.		
	lbs.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	grs.
Weight of shell	98	39	0	19	10	10	8	..		5	2	220
Bursting charge .	3	0	10	0	1¼	0	0¾	..		0	0	132
Total Weight, exclusive of fuzes .	101	41	10	19	11¼	10	8¾	..		5	2	352
Number of segments in shell . .	112	72	0	72	0	48	0	..			30	0
Each segment	3¼ oz.	2½ oz.		1¾ oz.		1½ oz.		..		1 oz.		

NOTE.—The bursting charge of 20, 12, 9, and 6-prs. is contained in an iron cylinder, the weight of which is not here included. This, with the concussion and time fuzes, brings up the weight.

47. *All the common shells,* 7-inch, 64-pr. and 40-pr. segment shells, *are filled with powder* in the ordinary manner, viz., from paper bags

in calico covers, if for Field or Siege service, and from loose powder if for Garrison, or Sea service.

48. The segment shells for the smaller natures, viz., 20-prs., 12-prs., 9-prs., and 6-prs., are each charged with a burster, containing powder, and a special one is used for each nature. That for the 20-pr., 12-pr., or 9-pr. is made from wrought-iron tubing, but of different lengths, whilst the 6-pr. is made of cast iron. To keep the burster in its place until the shell is required for use, a wooden plug covered with serge is placed between the burster and the gun metal fuze hole plug.

49. Loaded shells should never be fired with less than the authorized bursting charge, as premature explosions may occur when the guns are fired.

50. The proportion in which shot and shell is supplied for practice is about two-thirds shot to one-third shell. No scale of proportion for practice has yet been fixed for other than 12-pounder batteries.

51. *Fuzes* are of two kinds, viz., time, and percussion.

52. *The Time Fuze* is used for all natures of guns. As the fuze holes of 7-inch and 40-pr. shells and the 20-pr. *common* shells, in order to receive the pillar fuze, are larger in diameter than those in the smaller natures of shells, adapters are issued with the time fuzes, which enable them to be used with these shells.

The time fuze is ignited by the shock it receives when leaving the gun, and the moment at which the shell is required to explode is regulated by the set screw and scale, divided off into divisions corresponding to inches and tenths of elevation, around the periphery of the fuze. When this fuze is screwed home in the shell, it projects from it, and therefore does not permit of the shell being packed in the boxes; besides, by leaving the fuze in the shell, a great risk would be run of explosion from any accidental blow or fall.

53. *Adapters.*—The adapter consists of a brass collar, screwed on exterior of fuze, and made to fit the fuze hole in the shell.

54. *The Percussion Fuze* is used only with the 20-pr., 12-pr., 9-pr., and 6-pr. segment shells, and when in position for firing, it is between the burster and the gun metal screwed plug, or time fuze, if a time fuze is used.

CHAPTER IV.—ARMSTRONG FIELD GUNS.

Standing Drill.

66. The detachment, consisting of one non-commissioned officer and eight gunners, is drawn up two deep in rear of the gun, and told off from the right. The even numbers in the front rank and the odd numbers in rear, with the exception of No. 1, who falls in on the left of the front rank.

In numbering off the detachment, No. 1 takes a place to his front with his left foot, and faces to the right.

Position, and General Duties when in Action.

No. 1 stands on the right side of the gun, between the breech and wheel, points, commands, and adjusts the fuze.

No. 2 stands on the left side of the gun between the breech and wheel, takes out, and puts in the plug of the water bucket, screws up and unscrews the breech, puts in, and takes out the vent piece, makes ready, and fires.

No. 3 stands one yard in rear of and covering the right wheel, ships, and unships the handspike, puts in the shell and cartridge, and traverses (when necessary) with the handspike.

No. 4 stands one yard in rear of and covering the left wheel, sponges, and rams home.

No. 5 stands five yards in rear of the right wheel, and supplies No. 3 with ammunition from No. 7.

No. 6 stands in rear of the off limber box, prepares and serves out ammunition to No. 7.

No. 7 stands ten yards in rear of No. 5, and supplies him with ammunition from No. 6.

No. 8 stands in rear of the near limber box, and assists No. 6.

No. 9 attends the ammunition waggon.

Words of Command. Action. Load. Shell. Cartridge. Home. *The gun having been accurately laid.* Ready. Fire. Cease firing.

Changing Rounds when in "Action."

No. 1	becomes	No. 3	No. 8	becomes	No. 6
" 3	"	" 5	" 6	"	" 4
" 5	"	" 7	" 4	"	" 2
" 7	"	" 9	" 2	"	" 1
" 9	"	" 8			

No. 2 changes by the front.

Changing Rounds when the Gun is limbered-up.

No. 2	becomes	No. 4	No. 9	becomes	No. 7
" 4	"	" 6	" 7	"	" 5
" 6	"	" 8	" 5	"	" 3
" 8	"	" 1	" 3	"	" 2
" 1	"	" 9			

Form the Order of March.—Left Face.—At the word,—the detachment being formed two deep in rear of and facing the gun,—No. 1 gives the word to face to the left, faces with the detachment, steps to his left, and heads the rear rank.

Double March.—No. 8 countermarches to his right, followed by the remainder of the front rank, and doubles up on the right of the gun. No. 1 wheels to the right, followed by the rear rank, and moves up on the left of the gun.

Positions.—The odd numbers stand on the left, the even on the *right side of the gun,* in the following order :—

Nos. 2 and 3 in line with the axletree of the gun carriage.

Nos. 4 and 5 in line with the centre of the trail.

Nos. 6 and 7 in line with the axletree of the limber.

Nos. 8 and 9 in line with the splinter-bar.

The numbers stand covering one yard clear of the wheels.

No. 1 stands in line with the point of the near shaft, and two yards from it.

Drill with diminished Numbers.

2 Nos.

No. 1 commands, lays, serves ammunition, makes ready, and fires.

No. 2 sponges, rams home, takes out, and puts in vent-piece, screws up, and unscrews the breech.

3 Nos.

No. 1 commands, lays, makes ready, and fires.

No. 2 unscrews the breech, takes out the vent-piece, sponges, and rams home.

No. 3 serves ammunition, puts in the vent-piece, and screws up the breech.

4 Nos.

No. 1 commands and lays.

No. 2 screws up, and unscrews the breech, puts in and takes out the vent-piece, makes ready, and fires.

No. 3 serves ammunition, and traverses with the handspike when necessary.

No. 4. sponges, and rams home.

75. DRILL FOR 40-POUNDER, AND 20-POUNDER ARMSTRONG GUNS, MOUNTED ON TRAVELLING CARRIAGES, ON GROUND PLATFORMS, AND FIRING THROUGH EMBRASURES.

One non-commissioned officer, and nine gunners.

Detachment. The detachment is told off as for drill with Armstrong field guns.

Telling off. The detachment is marched into the battery and halted to the left rear of the gun to be served, as with the common heavy ordnance.

Taking post under cover is performed as with the ordinary gun, the *Taking Post.* only difference being that the front rank (the even numbers) are on the left side of the gun, the rear rank (the odd numbers) on the right.

General Duties. No. 1 points, commands, and regulates time fuze.
No. 2 attends vent-piece and breech screw.
No. 3 assists 2, and loads.

No. 4 sponges, rams home, and traverses.

No. 5 sponges, rams home, and traverses.

No. 6 hands sponge and rammer to 4, and elevates.

No. 7 supplies 3 with wad and cartridge, and fires.

No. 8 supplies cartridges from the magazine, and assists 9 in preparing shells.

No. 9 assists to prepare shells, brings them up, and gives them to No. 1.

No. 10 fixes lubricator to cartridge, and serves out ammunition.

The first seven numbers run up.

In changing round,

1	becomes	10	4	becomes	2
10	,,	9	2	,,	3
9	,,	8	3	,,	5
8	,,	6	5	,,	7
6	,,	4	7	,,	1

CHAPTER V.—ON RANGE, ELEVATION, AND DEFLECTION.

77. It should be observed that for certain reasons a constant elevation of 6′ has been given on the sights of the Armstrong guns of all calibres.

The ranges recorded in the following tables are therefore virtually those due to the apparent elevation plus the constant 6′ given as described. In every case the gun is supposed to be pointed at the object intended to be struck, and the elevation is what should strike that object. The ranges therefore are not, as heretofore usual, ranges to the first graze on the plane.

78.—7-INCH ARMSTRONG GUN.

Table of Ranges with Solid Shot, Common or Segment Shells for charge 11 *lbs.*

(Weight of shell filled, 98 lbs. Bursting charge, 8 lbs.)

Weight of Gun, 81 cwt. 1 qr. 4 lbs.—Length, 10 feet.—No. of Grooves, 76.—Charge, 12 lbs.—Spiral, 1 turn in 37 Diameters.

Elevation.		Allowance for constant Deflection of the Gun.	Range.	Time of Flight.	Remarks.
Degrees.	Minutes.	Minutes.	Yards.	Seconds.	
0½	..	7 Right	280	1·0	
1	..	5 ,,	510	1·7	
2	..	4 ,,	920	3·0	
3	..	2 ,,	1290	4·4	
4	..	1 ,,	1620	5·5	
5	..	1 Left	1950	6·7	
6	..	4 ,,	2260	7·8	
7	..	6 ,,	2580	8·9	
8	..	9 ,,	2880	10·0	
9	..	12 ,,	3180	11·1	
10	..	15 ,,	3500	12·2	

79.—110-POUNDER ARMSTRONG GUN.

Weight of Gun, 81 cwt. 1 qr. 16 lbs.—Length, 10 feet.—No. of Grooves, 76.—Charge, 12 lbs.—Spiral, 1 turn in 37 Calibres.

Table of Ranges.

Elevation.		Allowance for constant Deflection of the Gun.	Range.	Time of Flight.	Remarks.
Degrees.	Minutes.	Minutes.	Yards.	Seconds.	
0½	..	..	300		
1	..	..	560		
2	..	..	1010		
3	..	..	1420		
4	..	..	1770		
5	..	..	2120		
6	..	..	2430		
7	..	..	2740		
8	..	..	3050		
9	..	..	3360		
10	..	..	3670		

80.—40-POUNDER ARMSTRONG GUN.

Table of Ranges with Solid Shot, Common or Segment Shell.

Weight of Gun, 32 cwt. 2 qrs. 0 lbs.—Length, 10 feet.—No. of Grooves, 56.—Charge, 5 lbs.—Spiral, 1 turn in 36½ Calibres.

Elevation.		Allowance for constant Deflection of the Gun.	Range.	Time of Flight.	Remarks.
Degrees.	Minutes.	Minutes.	Yards.	Seconds.	
0½	..	7 Right	400	1·2	
1	..	5 ,,	620	1·9	
2	..	3 ,,	1020	3·1	
3	..	2 ,,	1400	4·3	
4	..	1 ,,	1760	5·4	
5	..	1 Left	2120	6·5	
6	..	4 ,,	2500	7·8	
7	..	7 ,,	2800	8·8	
8	..	9 ,,	3120	9·9	
9	..	13 ,,	3390	11·0	
10	..	15 ,,	3660	12·3	

82.—20-POUNDER ARMSTRONG L. S. GUN.

Table of Ranges with Solid Shot, Common or Segment Shell.

Weight of Gun, 16 cwt. 1 qr. 18 lbs.—Length, 8 feet.—No. of Grooves, 44.—Charge, 2½ lbs.—Spiral, 1 turn in 38 Calibres.

Elevation.		Allowance for constant Deflection of the Gun.	Range.	Time of Flight.	Remarks.
Degrees.	Minutes.	Minutes.	Yards.	Seconds.	
0½	..	..	240	0·7	
1	..	..	450	1·4	
2	..	..	850	2·7	
3	..	..	1180	3·9	
4	..	..	1500	5·0	
5	..	..	1820	6·1	
6	..	..	2110	7·1	
7	..	..	2400	8·2	
8	..	..	2690	9·2	
9	..	..	2920	10·2	
10	..	..	3250	11·3	

83.—SHORT 20-POUNDER ARMSTRONG GUN, S. S.

Table of Ranges with Solid Shot, Common or Segment Shell.

Weight of Gun, 12 cwt. 1 qr. 0 lbs.—Length, 5 feet 6 inches.—No. of Grooves, 44.—Charge, 2½ lbs.—Spiral, 1 turn in 38 Calibres.

Elevation.		Allowance for constant Deflection of the Gun.	Range.	Time of Flight.	Remarks.
Degrees.	Minutes.	Minutes.	Yards.	Seconds.	
0½	..	..	280	1·0	
1	..	..	460	1·6	
2	..	..	800	2·8	
3	..	..	1080	3·8	
4	..	..	1380	4·8	
5	..	..	1620	5·8	
6	..	..	1820	6·9	
7	..	..	2140	7·9	
8	..	..	2370	8·9	
9	..	..	2600	9·9	
10	..	..	2820	10·9	

84.—12-POUNDER ARMSTRONG GUN.

Table of Ranges with Shell.

Weight of Gun, 8 cwt. 2 qrs. 18 lbs.—Length, 7 feet.—No. of Grooves, 38.—Charge, 1½ lb.—Spiral, 1 turn in 38 Calibres.

Elevation.		Allowance for constant Deflection of the Gun.	Range.	Time of Flight.	Remarks.
Degrees.	Minutes.	Minutes.	Yards.	Seconds.	
0½	..	9 Right	350	1·1	
1	..	7 ,,	620	1·9	
2	..	6 ,,	1060	3·2	
3	..	3 ,,	1400	4·4	
4	..	2 ,,	1740	5·6	
5	..	1 Left	2060	6·7	
6	..	4 ,,	2330	7·7	
7	..	7 ,,	2600	8·8	
8	..	10 ,,	2860	9·4	
9	..	13 ,,	3120	10·5	
10	..	15 ,,	3340	11·6	

85.—6-POUNDER ARMSTRONG GUN.

Table of Ranges with Shell.

Weight of Gun, 3 cwt. 0 qrs. 12 lbs.—Length, 5 feet.—No. of Grooves, 32.—Charge, 12 oz.—Spiral, 1 turn in 30 Calibres.

Elevation.		Allowance for constant Deflection of the Gun.	Range.	Time of Flight.	Remarks.
Degrees.	Minutes.	Minutes.	Yards.	Seconds.	
0½	..	9 Right	360	1·1	
1	..	7 ,,	560	1·8	
2	..	6 ,,	900	3·0	
3	..	3 ,,	1180	4·0	
4	..	2 ,,	1460	5·1	
5	..	1 Left	1710	6·1	
6	..	4 ,,	1950	7·1	
7	..	7 ,,	2180	8·0	
8	..	10 ,,	..		
9	..	13 ,,	..		
10	..	15 ,,	..		

86.—**Table** showing the Degrees of Elevation, and Amount of Deflection which it is necessary to give for certain Ranges up to 3400 yards. The Table has been compiled from practice with the 12-pounder Gun; Charge, 1½ lb.; Weight of Shell, 11¾ lbs. But the Ranges of the 110 and 40-pounder Guns are so similar that the Table may also be used for them.

	Ranges.	Elevation.		Deflection.	Time of Flight.
	Yards.	Deg.	Min.	Min.	Seconds.
	100	..	..	12 Right	0·80
	200	..	..	11 ,,	0·16
	300	..	..	11 ,,	0·25
	400		18	10 ,,	0·35
	500		32	10 ,,	0·46
	600		47	9 ,,	0·58
Add 15′ for every 100 yards.	700	1	2	9 ,,	1·10
	800	1	17	8 ,,	1·22
	900	1	32	8 ,,	1·35
	1000	1	47	7 ,,	1·50
	1100	2	4	6 ,,	2·60
Add 17′ for every 100 yards.	1200	2	21	5 ,,	2·23
	1300	2	38	4 ,,	2·39
	1400	2	55	4 ,,	2·58
	1500	3	12	3 ,,	3·17
	1600	3	32	3 ,,	3·35
	1700	3	52	2 ,,	3·53
	1800	4	12	1 ,,	4·11
	1900	4	32	1 ,,	4·30
	2000	4	52	0 ,,	4·49
	2100	5	12	1 Left	5·10
	2200	5	32	2 ,,	5·32
	2300	5	52	3 ,,	5·53
Add 20′ for every 100 yards.	2400	6	12	4 ,,	6·15
	2500	6	32	5 ,,	6·36
	2600	6	52	6 ,,	7·00
	2700	7	12	7 ,,	7·23
	2800	7	32	8 ,,	7·46
	2900	7	52	9 ,,	8·10
	3000	8	12	10 ,,	8·30
	3100	8	32	11 ,,	8·56
	3200	8	52	12 ,,	9·22
	3300	9	12	13 ,,	9·48
	3400	9	32	14 ,,	10·14

Range, and Deflection.

87. The velocity of these projectiles diminishes slowly with the range; consequently, the range will be nearly as the time of flight. The velocity at the muzzle is about 1200 feet per second; at 1000 yards, about 920 feet; and at 2000 yards about 800 yards per second.

From 500 to 1000 yards, 1 minute of elevation gives 7 yards in range.

From 1000 to 3000 yards, 1 minute gives 6 yards; at distances above 3000 yards, 1 minute gives 5 yards.

88. *The Armstrong guns always throw to the right, increasing with the range; this is termed a constant deflection, and must be allowed for. This allowance is made by placing the rear sight so as to be correct at 2000 yards; at distances below 2000 yards, the error will be so small that it may be disregarded.

From 2000 to 2500 yds. give 3′ deflection left.
From 2500 to 3000 yds. give 5′ deflection left.
From 3000 to 3500 yds. give 9′ deflection left.
From 3500 to 4000 yds. give 15′ deflection left.

To these must be added the allowance for wind, and this increases as the squares of the times of flight.

A practical rule is, that each minute of deflection on the sight gives a difference of an inch in every hundred yards of range.

Suppose, then, a trial shot to be fired at 8 degrees of elevation, which gives an average range of 3000 yards, the constant deflection at 3000 yards requires, as we have seen, 5′ deflection left; if, then, having given these five minutes, we estimate that the shot has struck two yards to the right of the object aimed at, we have $2 \times 36 = 72$ inches divided by 30, the number of hundreds of yards of range $= 2\frac{1}{2}$ minutes nearly, deflection to the left to be added to the 5′ constant deflection.

Deflection on the sight is always given to that side to which it is wished to throw the shot; thus 5 minutes' deflection to the right, at a range of 1,200 yards, will throw the shell 12 times 5 inches, or 5 feet, to the right.

Aim.

89. The breech tangent sight consists of a piece of metal having two slits, in the form of a cross. The trunnion sight terminates at the top in a sharp point, with an edge on each side.

Direction is given by bringing the centre of the cross, the top of the point of the trunnion sight, and the object aimed at, in the same straight line.

Elevation is given by bringing the centre line of the horizontal slit of the tangent scale, the top of the edges of the trunnion sight, and the object, in the same horizontal plane.

This method of using an imaginary point and line found by the eye,

* Should a plan proposed by Captain Yonge be adopted, there will be no necessity to make any allowance except for the wind; paragraphs concerning the constant deflection may then be erased.

gives much greater facility and accuracy in laying than can be obtained by the ordinary method. The edges of the cross slits in the breech sight are bevilled off at the back to prevent cross shades, and to allow of a free passage of light to the eye.

Ricochet Firing.

90. Experiments which have been carried on by the Ordnance Select Committee show that Armstrong guns can be fired with reduced charges, so as to have a high descending angle and still retain accuracy, and uniformity of range; they are thus adapted for silencing guns covered with traverses, sunken defences, &c., although not equal to the smooth-bored guns with round shot for ricochet firing, that is, to proceed through a work by short bounds, making more than one graze in it.

It has been ascertained that the initial velocity of the 12-pr. shell is as follows:—

With a charge of 6 oz., 600 feet per second.
8 „ 620 „
10 „ 732 „

And it is probable that these velocities will be very near the truth for charges of the other natures bearing the same proportion to the weight of the shot, viz., for 40-pr. 20 oz., 26·6 oz., 33·8 oz.; for the 20-pr., 10·5 oz., 14 oz., and 17·5 oz. Their mechanical effects can, therefore, be easily compared with those of smooth-bore projectiles, if we also ascertain the velocity of the latter with small charges. This has not at present been done; but by calculation it would appear that the velocity of a 32-pr. shot with 22 oz. of powder (the charge used during the experiments) is about 715 feet per second, being about 100 feet greater than that of the 12 and 20-prs., and 120 feet greater than that of the 40-pr. The elongated projectiles preserve their velocity rather better than the round shot; but, on the whole, although it appears sufficiently great to produce destructive effect on the artillery *matériel* they strike, it must be less than that of the round shot, and consequently their mechanical effect less also; on the other hand, the large bursting charges of the elongated shells will make them much more destructive to traverses and solid obstacles as well as troops.

The following Table contains the observed first and second grazes of a part of the practice carried on during the experiment:—

COMPARISON of 1st and 2nd GRAZES of ARMSTRONG PROJECTILES.

Gun.	Charge.	Elevation.	No. of Rounds.	Mean Range. 1st Graze.	Mean Range. 2nd Graze.	Difference of 142 Grazes.	Deflection. 1st Graze.	Deflection. 2nd Graze.	Soil.
Pr.	Oz.	Degs.		Yards.	Yards.	Yards.	Right.	Right.	
12	6	7	2	765	1290	525	..	23	Good Turf.
	,,	10	2	937	1331	394	..	75	
	8	5	3	729	1513	784	..	63	
20	16	5	3	744	1536	792	..	113	
	,,	7	5	1009	1600	591	..	65	
	18	5	3	828	1405	577	..	47	
	,,	7	4	1112	1795	683	..	71	
	20	7	5	1195	2188	993	2·4	50	Wet Sand.
	,,	10	5	1650	2435	785	6·7	61	
40	32	5	5	883	1683	800	1·1	47	
	,,	7	5	1173	2186	1013	2·7	80	
	36	5	5	1004	2058	1054	1·7	38	
	,,	7	5	1306	2422	1116	2·7	60	
	40	5	5	1083	1933	850	1·7	86	
	,,	7	5	1448	2626	1178	3·7	116	

TABLE giving the APPROXIMATE ELEVATIONS necessary to pitch an ARMSTRONG SHOT, or SHELL into a WORK at the DISTANCES specified, and with the CHARGES given.

Distance of Object.	L. S. 12-Pounder. Elevation for			L. S. 20-Pounder. Elevation for			L. S. 40-Pounder. Elevation for			
	6 oz.	8 oz.	10 oz.	14 oz.	16 oz.	18 oz.	24 oz.	28 oz.	32 oz.	36 oz.
Yards.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
500	5·60									
600	5·54									
700	6·42	4·15		6·20	4·50		5·30			
800	8·00	5·10		7·40	5·30	4·50	6·15	5·20		
900	9·30	6·50	4·40	7·46	6·13	5·30	7·80	6·50	5·50	
1000		6·58	5·20	8·30	6·56	6·10	7·55	6·45	5·45	5·00
1100		8·60	6·40	9·10	7·40	6·50	8·35	7·30	6·30	5·40
1200		9·20	6·46	9·50	8·25	7·40	9·25	5·12	7·10	6·20
1300			7·40		9·10	8·20		9·00	8·00	7·00
1400			8·40		10·00	9·13		9·46	8·45	7·40
1500			9·40			9·50			9·30	8·25
1600										9·15

PART VII.

EXERCISE OF ROCKETS.*

THE 24-pounder is used for siege purposes. The 12, and 6-pounders are for service in the field.

EXERCISE OF 12, AND 6-POUNDER, OR FIELD ROCKETS.

Telling off the Detachment.

The detachment falls in, in rear of and facing the carriage, and is told off as for gun exercise.

Disposition, and Duties of a Detachment of Seven men, with a 12, and 6-pounder Rocket.

No. 1 stands one yard in rear of the tube, points, and commands.

3 stands on the left of the tube, in line with its centre, elevates, and traverses.

2 stands on the right of the tube, in line with the centre, elevates and traverses.

5 stands on the left of the tube, in line with the rear of it, primes, and fires.

4 stands on the right of the tube, in line with the rear of it, brings up rockets, arranges the priming, and loads.

7 stands in rear of the carriage, and prepares rockets.

6 stands in rear of the carriage, assists No. 7 in preparing rockets.

The following is the Proportion of Stores furnished with Field Carriages.

Two hundred and sixteen Rockets with sticks, with 6-pounder.
One hundred Rockets with sticks, with 12-pounder.

One rocket frame comprising two cheeks, a prypole, elevating bar, and tangent scale. *One tube pocket with tubes.* *One lanyard with hook* for friction tubes.	With both natures.

To every other equipment not exceeding 144 Rockets.

One stick for each Rocket.
One tube pocket with tubes.
One lanyard with hook for friction tubes.

One angle. *One plummet with line.* *One elevating chain.* *Two guy ropes.* *Two additional pieces* for the cheeks.	With 24-pounder.

* *Note.—From* "MANUAL OF ARTILLERY EXERCISES," 1860.

PART VIII.

HORSES.

THE average weight of Artillery horses is 10 cwt. 2 qrs.

An allowance of 27 square feet is generally made for each horse standing at picket, or three feet in breadth, and nine feet in depth. A horse should seldom be made to draw more than three cwt. besides the weight of the carriage. With great burthens, less weight must be allowed for each horse to draw than with medium burthens; as with a team of horses, the leaders cannot draw so much as the horses nearer the carriage, and the disadvantage must increase in proportion to the lengthening of the team.

A Team of	4 horses	may each draw	6 cwt.	Total,	24 cwt.
	6 do.	do.	5 do.		30 do.
	8 do.	do.	4 do.		32 do.
	12 do.	do.	4 do.		48 do.

These weights include the carriages. It is usual, however, in heavy carriages, to reckon all their weight exceeding twelve cwt. as part of the load.

The most useful mode of applying a horse's power is in draught, and the worst is in carrying a load. This is owing to the structure of the animal. It has been found that three men, carrying each 100 lb., will ascend a hill with greater rapidity than one horse carrying 300 lb. When a horse has a large draught in a waggon, however, it is found useful to load his back to a certain extent; this prevents him from inclining so much forward as he would otherwise do, and consequently frees him from the fatigue of great muscular action. The best disposition of the traces in draught is when they are perpendicular to the collar; when the horse stands at ease, the traces are then inclined to the horizon, at an angle of about 15°; but when he leans forward to draw, the traces should then become nearly parallel to the road. The most proper inclination, however, is determined from the relation which subsists between the friction, and the pressure, in every particular case.

When a horse is employed in moving a machine, by travelling in a circular path, the diameter of the path ought not to be less than twenty-five or thirty feet, and in most cases forty feet should be preferred: at all events, it must not be less than eighteen feet.

Maximum quantity of Labour.

The following Table shows the Maximum quantity of labour, which a horse of average strength is capable of performing at different

velocities, on canals, railways, and turnpike roads; but in comparing this table with practice at the higher velocities, it is reckoned necessary to add one-third more than the useful effect for the total mass moved.

Velocities per hour.	Day's work.	Force of traction.	Useful effect per Day for a distance of one Mile on a		
			Canal.	Level railway.	Level road.
Miles.	Hours.	lb.	Tons.	Tons.	Tons.
2½	11·5	83⅓	520	115	·14
3	8·		243	92	12
3½	5·9		153	82	10
4	4·5		102	72	9
5	2·9		52	57	7·2
6	2·		30	48	6
7	1·5		19	41	5·1
8	1·8		12·8	36	4·5
9	·9		9	32	4
10	·75		6·6	28·8	3·6

Result of experiments with a light four-wheeled cart, weighing with its load 1000 lb., drawn upon different sorts of roads (12½ lb. having been deducted from the force of traction for the friction at the axles, which were of wood).

Turnpike-road, hard, dry	. .	18	Force of traction required to move the carriage, independent of the friction at the axles.
Do. dirty	. . .	26½	
Do. new gravelled	.	130½	
Loose sandy road	. . . .	191½	

Note.—An ox can draw about 4 cwt., and a pair of oxen 9 cwt., on a level road.

LASSO HARNESS.

Lasso harness consists of a brown leather surcingle, and one trace. The surcingle is rather wider than a common girth, and is composed of two pieces (joined together by rings), one of which is placed over the saddle, and the other round the belly of the horse. There are also rings at the end of the surcingle, which is drawn very firmly round the horse, and fastened tight by lapping a white leather thong (fixed at one end of the surcingle) through these rings. There are two descriptions of traces, one being 8, and the other 12 feet long. They have hooks at each end, and, when the lasso harness is made use of by cavalry, &c., to assist draught horses in moving very heavy carriages, or in dragging guns, &c., up steep hills, one of these hooks is fastened to a ring in the surcingle, and the other to the carriage, &c.

Lasso harness may be advantageously employed with all horses; even those unaccustomed to draught having been found perfectly tractable, and efficient the first time they were required to draw by

means of the lasso. When two horses are in draught, the traces must be inside, and each rider should keep his horse's croup a little outwards.

HORSE-SHOES.

There are three sizes of horse-shoes in the service, and also a smaller size made for mules.

	Size.		lb.	oz.
Weight of set	1st	(not including the weight of nails) . . .	7	0¼
	2nd	do. do. . . .	6	4½
	3rd	do. do. . . .	4	8½
	Mules	do. do. . . .	2	14

NAILS.

LENGTH, WEIGHT, NUMBER, ETC.

1st size. Largest.	No. of nails*	8	9	10	5½ oz.	Weight of set. 32 Nails.
	No. of each required . . .	16	8	8		
2nd size.	No. of nails*	7	8	9	4½ oz.	
	No. of each required . . .	8	12	12		
3rd size.	No. of nails*	5	6	7	3½ oz.	
	No. of each required . . .	8	8	16		

* *Note.*—These several nails are known by farriers according to their No.—viz., when they say shoes require nails, Nos. 8, 9, 10, this implies nails of 8, 9, and 10 pounds per thousand nails.

No. of Nails.	Length of Nails.	Weight of 1000 Nails.
188	2¾ inches.	10 lb.
187	2½ —	9 —
186	2⅜ —	8 —
185	2¼ —	7 —
184	2⅛ —	6 —
183	2 —	5 —

FORAGE.

Method observed in carrying one day's forage.

Non-commissioned Officers, and Trumpeters.—One feed of oats in the nose-bag, and buckled to the near-ring of the saddle. Three feeds in the corn-bag, and carried across the saddle. Twelve pounds of hay twisted, and rolled up into two bundles, each nine inches long, carried at the ends of the kitt, and made fast with the forage cord, one end to pass in front, and the other in the rear of the kitt, making it fast by two hitches.

Drivers.—One feed of oats for each horse, carried in the nose-bags, and made fast to the rear staples of the off-horses' saddles. Three feeds for each horse (six feeds) in the corn-bag, carried across the saddle of the near horse. The hay is twisted and rolled up into two bundles of twelve pounds, each eighteen inches long; carried on the off-horse at the ends of the kitt; the end of one forage cord passing in front of the kitt, the end of the other forage cord passing in rear of the kitt, both ends being made fast by two half hitches.

If a waggon accompanies the battery, the officers' horses' forage will be carried in it; if not, the oats are to be divided between the subdivisions, and the hay carried on the foot-board in front of the body of the waggon.

In heavy marching order, when forage is not ordered to be carried.

NON-COMMISSIONED OFFICERS, AND TRUMPETERS.—The nose-bags are rolled up and buckled to the near-ring of the saddle. Forage cord, currycomb and brush, mane-comb, picker, and sponge, are made fast, to the off-ring.

DAILY RATION FOR ONE HORSE.

	Oats. lb.	Hay, or Grass. lb. lb.	Straw. lb.
In Quarters . . .	8	18 ..	6
In Barracks . . .	10	12 or 36	8

A load of Hay, or Straw . . . . . . 36 trusses.
A truss of Hay . . . . 56 lb.
Ditto Straw . . . . 36 lb.

VETERINARY DIRECTIONS.*

The ordinary dose of every Mass is One ounce (Avoirdupois).

No. I.—CATHARTIC MASS.

Aloes, Barbadoes . . .	8 parts.
Olive Oil	1 „
Treacle	3 „

Dose, from 6 to 7½ drams of the mass, which contains 4 and 5 drams of aloes respectively.

Any horse to whom a dose of physic is given, should be fed on bran mashes, in lieu of corn, until its operation has ceased. If there be no cause for its immediate administration, let ample bran marshes be given, by way of preparation, in lieu both of hay, and corn, during one day, and the ball administered the following morning, after the horse is sufficiently watered, and a couple of hours at least before his bran mash be given him. Exercise, also, during the day is advisable. The following day, early in the morning, after the horse has had water, with the chill taken off, offered him, till he refuses to drink more, let him be walked out briskly for one hour, unless he purge, in which case let him be returned to the stable, littered down, frequently watered, and plentifully supplied with bran mashes. But should the physic not operate at the expiration of his exercise, nor after he has remained the four succeeding hours in the stable, let him be exercised for another hour; and he may be gently trotted at this time should he still show no signs of purging: let it be here understood, however,

* Whenever a *Veterinary* Surgeon is present, these Directions are to be *considered in abeyance.*

that in no case is a horse in physic to be galloped. To insure purgation, water is no less requisite than exercise.

Should the animal continue to purge on the third day, let him be kept short of water, and without exercise; if the purging still continue, give wheaten flour gruel, and hay; no exercise. As soon as his dung shall have put on its natural appearance, and consistence, the usual ration of provender may be restored, and he may return to duty.

When a sick, or lame horse requires physic, to which exercise would be injurious, or if he has not been properly prepared with bran mashes, the dose may be increased by one dram; and to him the ball may be given at any time, in order that its operation may be as speedy as possible. A dose of physic should never be repeated until the expiration of seven clear days from the setting of the previous dose.

Horses suffering from cough, discharge from the nose or inflammation of the lungs, are not to have purgative medicine administered, but the febrifuge, or sedative mass should be given.

No. II.—Febrifuge Mass.

Nitrate of Potass . . .	3 drams.
Tartar Emetic	2 scruples.
Camphor	1 dram.

Common mass, a sufficient quantity to form a ball, to weigh one ounce, for one dose, which may be given once, or twice a day, for a day or two.

In coughs, or discharge from the nose in which fever is present, this mass is especially useful. Let the animal be warmly clothed, littered down, be kept quiet in a well-ventilated box, and fed on equal parts in bulk, of bran and oats, mixed with cold water; head steamed with hot water, and a little hay, in a bucket.

No. III.—Sedative Mass.

Extract of Belladonna .	2 drams.
Nitrate of Potass . . .	3 "
Tartar Emetic . . .	1 "
Camphor	1 "

Common mass, a sufficient quantity to form a ball to weigh one ounce, which may be repeated once, or twice a day, for two, or three days.

In case of inflammation of the lungs, these balls are especially beneficial. After having drawn from five to eight quarts of blood, according to the violence of the symptoms, and the apparent strength of the animal, give a sedative ball once, or twice a day at regular intervals. Let the sides of the chest be well rubbed with some of the blistering liquid, clothe warmly, rub the legs, and bandage with flannel; keep the stable well ventilated.

Should the symptoms be the same the next day, and the blister has

not risen, it may be repeated with the additional application of it to the chest; also, if the cough be frequent, to the throat;—the sedative balls being continued, and clysters given.

No. IV.—Diuretic Mass.

Nitrate of Potass Resin Hard Soap	Equal parts. Dose, one ounce.

Diuretic balls may be given, one every third night, in all cases in which they may be required: seldom is it necessary to administer one every other night, and still more rarely every night.

Should the flow of urine prove abundant, the horse frequently making efforts to stale, and groaning in so doing; or, if he cannot stale, but appear to experience pain about the loins and hips, and be stiff in moving those parts, diuretic balls must on no account be given. Diuretics are beneficial in recent swelling of the legs: linen bandages, and walking exercise may be had recourse to at the same time. Diuretics are also useful in watery farcy, dropsy, and puffy or watery swellings of all kinds.

No. V.—Alterative Mass.

Aloes, Barbadoes . . .	2 drams.
Ginger	1 dram.

Common mass sufficient to form a ball to weigh one ounce.

To ill-conditioned horses that do not thrive, notwithstanding they eat, and appear otherwise in health; to horses that rub themselves, or that have small lumps or bare places upon the skin (not mange), one of these balls may be given every fourth day, but not more than three balls altogether.

Bruised corn, hay cut into chaff, bran, and frequent and full supplies of water, contribute to restore such horses to condition. Walking exercise once, or twice a day, according to the strength of the horse, is also recommended.

No. VI.—Anti-Spasmodic Draught.

Spirits of Nitre	2 ounces.
Tincture of Opium . . .	1 ounce.
Water	4 ounces.

In the generality of cases of gripes this will prove sufficient; but if the horse be not better in one hour, the draught may be repeated with, or without the addition of half a pint of linseed oil. Clysters also will be found of great benefit. When the horse continues alternately to lie down, and rise in the stall, and to roll upon his back, relief will frequently be given by walking exercise for ten minutes.

Those cases in which the symptoms do not intermit, and in which

the pulse and breathing are much quickened, are not gripes, but inflammation of the bowels. Take away from six to eight quarts of blood without loss of time, and give a draught composed of aloes, four or five drams; powdered opium, two drams, dissolved in one pint of warm water; give frequent clysters of warm soap and water; rub well upon the belly a strong mustard poultice, composed of mustard, warm water, and liquid ammonia, or oil of turpentine, or a liniment composed of equal parts of oil of turpentine, and liquid blister. Hand-rub and bandage legs—clothe warmly.

If the symptoms do not abate, give powdered opium, one dram every two hours in warm water; continue clysters, and repeatedly offer the horse warm water to drink. The mustard poultice should also be repeated.

No. VII.—Vermifuge, and Tonic Powder.

Sulphate of iron, 6 drams divided into twelve doses, is a good remedy for worms—one dose to be given once a day in some bran mash, until the number is consumed. The horse may continue to work.

It also is useful as a tonic, given in the same manner, the dose being doubled to horses that are low in condition, or recovering from the effects of disease, the medicine being aided by generous feeding.

No. VIII.—Anti-purgation Mass.

Extract of Catechu . . .	1 dram.
Cinnamon Bark	1 ,,
Powdered Opium	½ ,,

Common mass—sufficient to form a ball to weigh one ounce.

The above mass is very useful in all cases of excessive purging, either from the effects of disease, or from an overdose of purgative medicine. The ball may be repeated two or three times a day, thick wheaten gruel being given at the same time.

No. IX.—Discutient Powder.

Sulphate of Zinc . . . 4 drams.

This, mixed with one quart of cold water, will be found a very useful application to sore backs, withers, shoulders, and to recent swellings from blows or injuries of any kind. Bandages wetted with this lotion may be used for sprains of the joints, and back sinews.

No. X.—Astringent Ointment.

Acetate of Lead	1 part.
Lard	3 parts.

This will be found useful in cases of grease, where the discharge is but little, and not very offensive. Apply a little to the heel, then a

piece of fine tow, and over that a tailed bandage. Give walking exercise, and a diuretic ball occasionally. But should there be much swelling, and the discharge copious and fetid, apply a warm bran poultice, over which sprinkle some powdered charcoal, feed on bran, and give a mild dose of physic. When this treatment has had the desired effect, the ointment may be used with advantage.

No. XI.—Ophthalmic Powder.

Sugar of lead . . . . . 2 drams.

So long as the eyes appear red and inflamed, cold water alone should be made use of, and with it they should be kept continually wet. When the inflammation is abated, sponge the eyes and eyelids several times a day with a lotion, made by dissolving the sugar of lead in a quart of cold soft water.

In all cases where there is much inflammation, a dose of physic should be given.

No. XII.—Blistering Liquid.

Powdered Cantharides . . . 4 ounces.
Olive Oil . . . . 1½ pint.

This is very useful as a counter-irritant in all cases of internal inflammation (see Nos. 3, and 6). It is also useful in swellings, sprained joints or sinews, curbs, spavins, &c., after the inflammation attending these diseases has subsided.

No. XIII.—Digestive Ointment.

Common Turpentine } Equal parts,
Hog's Lard } melted together.

This ointment is the best application that can be made use of in cases of treads or wounds on the coronet, between hair and hoof; a small quantity is to be spread upon a plugget of tow, and bound on with a bandage. It is likewise a good dressing for broken knees (when the joint is not open) or cuts, to promote healthy action.

No. XIV.—Turpentine Liniment.

Oil of Turpentine } Equal parts.
Olive Oil }

In cases of sore throat, cough, and in all cases where a mild counter-irritant is required, this liniment will be found useful.

No. XV.—Hoof Ointment.

Tar } Equal parts,
Lard } melted together.

This ointment is intended for brittle feet, or such as have sandcracks; *also, with tow, to form* the stopping to be placed under leather soles.

PART IX.

Published by Permission of the Lords Commissioners of the Admiralty.

NAVAL GUNNERY.

INSTRUCTIONS FOR THE EXERCISE, AND SERVICE OF GREAT GUNS, ON BOARD HER MAJESTY'S SHIPS.

EVERY ship should be prepared to defend herself when attacked, on both sides. On assembling at quarters for action, or exercise, the men are to repair to their respective sides, according to their watches, providing and distributing the several articles allotted them.

The first captains, and half the crew of the guns (the men designated by the odd numbers), remain by their proper guns; the second captains, and the remainder (designated by the even numbers), man the guns on their right.

Stationary powdermen are allotted to every two guns: they are to have two cases: that containing the reserve cartridge is to be *hung up* in rear of the gun amidships.

An extra powderman, whose duty it will be to fetch powder from the magazine scuttle, and supply the stationary powderman, is to be allotted to every four guns, that the reserve cartridge may not at any time be left without protection.

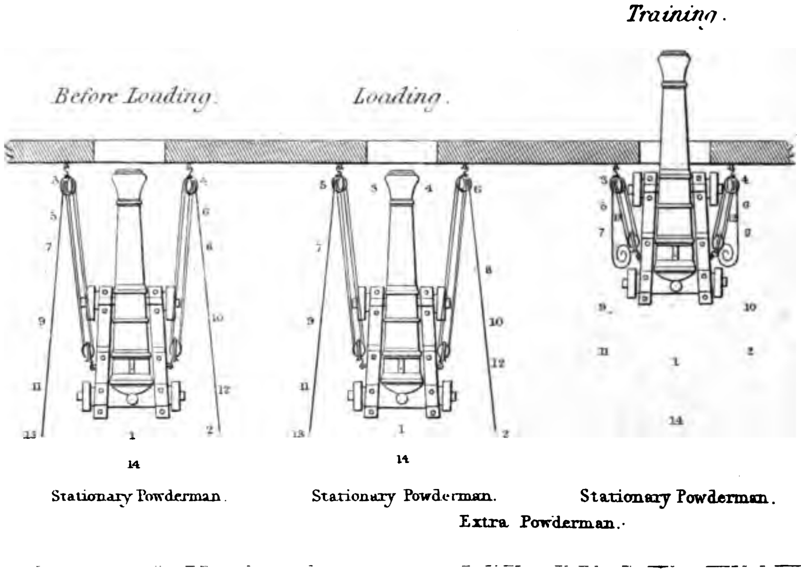
The gun and its opposite should bear the same number, beginning from forward with No. 1 on each deck.

The men appointed to work the gun are to be distinguished by numbers, which will be assigned according to the complement of men stationed at each gun, as hereafter described.

The crews and powdermen of the odd-numbered guns should be composed entirely of the starboard-watch, and the even-numbered guns of the port-watch; this will enable whole guns' crews to be worked together in their watch on deck, without disturbing the watch below, and will also enable the commanding officer to take the best men from both watches for the captains of the guns; they should be selected as much as possible from various parts of the ship, so that if a heavy loss of men should occur at particular guns, it would not be more severely felt at one station than at another. Petty officers, or leading men of stations, who are likely to be called upon in action to perform duties as such, are to be quartered at the guns nearest their work.

In assigning the duties, it is premised that the complements of all classes of Her Majesty's ships, small vessels excepted, will admit of the crew of each gun being composed of six persons and the powderman (the latter of whom is not to bear a number), by whom the principal duties in the working and providing for a gun are performed; the

POSITIONS.


Training.
Before Loading.
Loading.
Stationary Powderman.
Stationary Powderman.
Stationary Powderman.
Extra Powderman.
J. W. Lowry, fc.

first six are to be distinguished as the Gun numbers, and any additional men which its size may require, are to be considered as Auxiliaries, but they are to be equally instructed and rendered competent to perform the several duties of the gun. By this arrangement, one system will be applicable to the working of all the different natures of guns used at sea.

POSITIONS.

The crew, with the exception of the first and second captain and powdermen, are to stand with their faces turned obliquely towards the gun and the port, this position being best adapted to secure attention.

The two men whose numbers place them farthest from the ship's side, are to be termed right, and left rear-men. The guns on each deck are to be divided into two divisions, called the foremost, and after quarters; and an officer is to be appointed to command each.

Arrangements are to be made in the different magazines and passages, for the regular supply of powder to the several decks, under the superintendence of an officer, to prevent confusion from the intermixture of the cartridges; and the following rules should be observed in supplying the different decks with powder, namely:—

In frigates and two-decked ships, the lower, and main deck should be supplied from the fore magazine; and the quarter deck, and forecastle from the after magazine.

In three-decked ships, the lower, and middle deck from the fore magazine; main deck, quarter deck, and forecastle from the after magazine.

The fire screens are to be kept fixed, rolled up, and protected from the weather.

NOTE.—The above arrangement refers to Magazines as at present fitted.

ASSEMBLING AT QUARTERS.

The accustomed beat of the drum is for Action; the stationary powdermen repair to the magazine-scuttle for two cartridge-cases and two cartridges, and then return to their places in the rear of their guns amidships, ready to receive all further supply of powder from the extra powderman.

The Gun numbers provide the stores, and with the Auxiliaries cast loose their respective guns, which are to be searched, loaded with full charges, and single shot, and run out without further orders: but they are on no account to be fired without *distinct* orders from the upper deck.

NOTE.—The above arrangement, although it insures the guns being got quickly ready for action, does not preclude the commanding officer from giving orders on beating to quarters, to load with any other charge or projectile he may think best.

The accustomed beat of the drum with one roll is for Manual exercise, the same as for Action, but no powder is provided.

The accustomed beat of the drum with two rolls is to muster for inspection: the crews and powdermen repair to their respective sides, unless ordered to the contrary. The stationary and extra powdermen take their places in the rear of their guns amidships. "Fall out."

Detail for Placing the Men.

Take your place in the rear of the gun facing the port, as No. 1, the captain.

Take your place to the right of the gun close to the ship's side, No. 4, the sponger, standing quarter-face to the gun.

Take your place to the left of the gun, close to the ship's side, as No. 3, the loader, standing quarter-face to the gun.*

Take your place to the right of the gun next to No. 4, as No. 6, the assistant sponger.

Take your place to the left of the gun next to No. 3, as No. 5, the assistant loader.

Take your place to the right of No. 1, facing the ship's side, clear of the recoil, as No. 2, the second captain.

These six numbers are Gun numbers, and provide stores for, and cast loose, this gun and the gun on the right in their respective watches. All numbers above these are Auxiliaries, who cast loose this gun and the gun on the right in their respective watches.

Take your place to the	left	of the gun next to	No. 5	as No. 7.
"	right	"	No. 6	as No. 8.
"	left	"	No. 7	as No. 9.
"	right	"	No. 8	as No. 10.
"	left	"	No. 9	as No. 11.
"	right	"	No. 10	as No. 12.

And so on with higher numbers. "Close up."

"Gun Numbers."

1, 2, 3, 4, 5, 6.

"Auxiliaries."

7, 8, 9, 10, 11, 12, 13, 14, &c.

"Handspikemen."

9, 10.

"Rear-men."

14. The right rear-man. 13. The left rear-man.

(Or the two highest numbers.)

Gun numbers as placed in rotation on arriving at the gun:—

1. The captain.	6. The assistant sponger.
4. The sponger.	5. The assistant loader.
3. The loader.	2. The second captain.

Note.—The Gun numbers are never to be called unless ordered; and when so ordered, Auxiliaries, Handspikemen, Rear-men, and 1, The Captain, &c., are *to be called.*

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* This order applies to all Nos. but 1 and 2.

MANNING BOTH SIDES.

MAN BOTH SIDES. — Each watch will repair to its respective side, the odd numbers standing to the left of the left guns; even numbers to the right of the right guns.

Left guns			Right guns		
3	remains	3	4	remains	4
5	becomes	4	6	becomes	3
7	„	6	8	„	6
9	„	5	10	„	5
11	„	2	12	„	2
13	„	7	14	„	7
1	remains	1	2	„	1

NOTE.—The left guns are odd starboard, and even port. The right guns are even starboard, and odd port.

Guns' crews always man, and powder-boys always supply adjacent guns, when clearing for Action, or when fighting both sides.

With a crew of 11 men and upwards, and both sides manned, 2 is *always* to attend the train-tackle.

PROVIDING STORES

(*both sides manned*).

No. 1. Provides three vent plugs, priming wire, tube box, spare trigger line, vent bit, sees the lock fixed and fit for use, and places handspikes.

3. Shot, and grummet, spare breeching, wet swab, wads, and fuze wrench.

4. Sponge, rammer, worm, and fire-bucket.

Stationary, and extra powderman, two cartridge cases and two cartridges each.

NOTE.—With 68-pounders, and 10-inch guns, 3 should provide a bearer, and 4 should assist him in providing shot. Spare locks, and hammers are to be provided by the 2nd captain. Lanterns should be hung up amidships between the ports, and kept in order by the proper No. 4, arrangements being made for lighting them at night quarters.

Shells are always to be provided by the two highest numbers.

"MAN THE STARBOARD, OR PORT GUNS."

EXERCISE WITH 14 MEN TO A LOWER, MIDDLE, OR MAIN DECK GUN.

No. 1. The captain; commands, attends the breeching, primes, points, fires, and stops the vent.

2. The 2nd captain; assists 1, runs out, attends handspike, coin, and lock.

3. Loads, rams home, runs out, and trains.

4. Worms, sponges, rams home, runs out, and trains.

5. Gives shot and wad to 3, runs out, trains, and spans the breeching.

6. Gives sponge, rammer, and worm to 4, runs out, trains and spans the breeching.

7 and 8. Run out, and train.

9 and 10. Run out, and attend handspikes.
11. Runs out and attends handspike.
12. Runs out, and trains.
13. Runs out, trains, and brings up shell.
14. Attends train-tackle.

NOTE.—With more, or less than 14 men, the Exercise will be the same as above, except that the proper handspikemen will take the duties of 9 and 10, the assistant handspikemen, those of 11 and 2, and the rear-men, those of 13 and 14.

The captain of the gun is responsible that all stores and necessary gear are at the gun, and that throughout the Exercise all the Nos. perform their duties correctly.

EXERCISE WITH 9 MEN TO AN UPPER DECK GUN.

No. 1. The captain; commands, attends the breeching, primes, points, fires, and stops the vent.

2. The 2nd captain; assists 1, attends the apron, elevating screw, lock, and train tackle.

3. Loads, rams home, runs out, and trains.

4. Worms, sponges, rams home, runs out, and trains.

5. Gives shot and wad to 3, runs out, trains, and spans the breeching.

6. Gives sponge, rammer, and worm to 4, runs out, trains, and spans the breeching.

7 and 8. Run out, and attend handspikes.

9. Runs out, trains, and brings up shell.

NOTE.—With guns mounted on rear chock carriages having side levers for running out, Nos. 7 and 8 will shift the side tackles, and the left rear-man will attend roller handspike when necessary.

With guns mounted on Hardy's carriages, the Exercise will be the same as above, except that No. 4 will attend compressor when the gun is *out*, and No. 8 when the gun is *in*.

Handspikemen with 5, 6, or 7 men . .	5	and	6
„ „ 8, or 9 men . .	7	„	8
„ „ 10, or 11 men . .	7	„	8
and assistant handspikemen	9	„	2
Handspikemen with all Nos. above 11 .	9	„	10
and assistant handspikemen	11	„	2
Except with 10-inch, and 68-pounder guns, when assistant handspikemen will be .	11	„	12

With light guns it may be advantageous in some cases to double man the handspikes. The left rear-man will always fire with a hammer, or match, and the right rear-man will attend the train-tackle, except when he is handspikeman (when 2 will attend it) and in lower deck exercise (when *both* rear-men will attend it).

ASSEMBLING AT QUARTERS.

The accustomed beat of the drum is for Action, when the guns are to be cast loose, loaded, and run out without orders.

The accustomed beat of the drum with *one roll* is for Manual Exercise the same as for action, but without powder.

The accustomed beat of the drum with *two rolls* is to muster for Inspection.

Gun Nos., 1, 2, 3, 4, 5, 6.
Auxiliaries, 7, 8, 9, 10, 11, 12, 13, 14, &c.
Handspikemen, 9, 10. Rearmen, 14 the right rear-man, 13 the left rear-man (*or the two highest Nos.*).
1. The Captain. 4. The Sponger. 3. The Loader.
6. The Assistant-Sponger. 5. The Assistant-Loader.
2. The Second Captain.

MAN BOTH SIDES.

LEFT GUNS—3 remains 3; 5 becomes 4; 7, 6; 9, 5; 11, 2; 13, 7; 1 remains 1.

RIGHT GUNS—4 remains 4; 6 becomes 3; 8, 6; 10, 5; 12, 2; 14, 7; and 2, 1.

PROVIDING STORES.

(*Both sides manned.*)

No. 1.—Provides 3 vent-plugs, priming wire, tube box, spare trigger-line, vent bit, sees the lock fixed and fit for use, and places handspikes.

No. 3.—Shot, and grummet, spare breeching, wet swab, wads, and fuze wrench.

No. 4.—Sponge, rammer, worm, and fire bucket.

Stationary, and extra Powderman, two cartridge cases and two cartridges each.

NOTE.—With 68-pr., and 10-inch guns, 3 should provide a bearer, and 4 should assist him in providing shot. Spare locks, and hammers are to be provided by the 2nd Captain. Lanterns should be hung up amidships between the ports, and kept in order by the proper No. 4, arrangements being made for lighting them at night-quarters. Shells are always to be provided by the two highest Nos.

Stations for Casting loose a Lower deck Gun with 7 men.

(*Both sides manned.*)

NOTE.—No. 1 places handspikes, 3 and 4 bear out, and the other Nos. trice up the port; when the port is up, 1 provides stores, 2 and 7 cast off, and hook on train-tackle, 3 and 4 cast off muzzle-lashing, then provide stores and clear away breast-frapping, 5 and 6 clear away and shift side-tackles; when the side-tackles are clear, and train-tackle to the rear and luff choked, 1 gives the word "Elevate," sees the bed properly secured, and places coin at P. B., the gun is then run in, searched, loaded, and run out. While the gun is being elevated, 2 and 7 finish whatever is left undone, and whilst loading, 2 coils up the lashings, and 5 and 6 span the breeching.

MAN THE STARBOARD, OR PORT GUNS.

GREAT GUN

The men are only to learn the Exercise

Nos.	Exercise with 14 Men to a Lower, Middle, or Main Deck Gun.
1	The Captain; commands, attends the breeching, primes, points, fires, and stops the vent.
2	The 2nd Captain; assists 1, runs out, attends handspike coin, and lock.
3	Loads, rams home, runs out, and trains.
4	Worms, sponges, rams home, runs out, and trains.
5	Gives shot, and wad to 3, runs out, trains, and spans the breeching.
6	Gives sponge, rammer, and worm to 4, runs out, trains, and spans the breeching.
7 & 8	Run out, and train.
9 & 10	Run out, and attend handspikes.
11	Runs out, and attends handspike.
12	Runs out, and trains.
13	Runs out, trains, and brings up shell.
14	Attends train tackle.

Note.—With more, or less than 14 men, the Exercise will be the same as above, except that the proper handspikemen will take the duties of 9, and 10, the assistant handspikemen, those of 11, and 2, and the rear-men, those of 13, and 14.

The Captain of the gun is responsible that all stores and necessary gear are at the gun, and that throughout the Exercise all the Nos. perform their duties correctly.

Note.—Handspikemen, with 5, 6, or 7 men, 5 and 6; with 8, 9, 10, or 11 with 10 and 11 men, 9 and 2, and with all Nos. above 11, 11 and 2, except with No. 2 attends train-tackle when the right rear-man is handspikeman. A Sta- man to every

Stations for Casting Loose a Main Deck

Note.—No. 1 places handspikes, 3 and 4 bear out, and 1 and 2 trice up the tackle, 3 and 4 clear away, and unhook train-tackle, and provide stores, 5 and 6 is in; when the side-tackles are clear, and train-tackle to the rear, 1 gives the lower half-port; he then sees the bed properly secured and places coin at P. B., assist 2. With 5 men, 1 will hook on train-tackle. If the

"*Words of Command.*"—"Prime," "Point," "Elevate," "Ready,"

EXERCISE.

for the Gun at which they are quartered.

Nos.	Exercise with 9 Men to an Upper Deck Gun.
1	The Captain; commands, attends the breeching, primes, points, fires, and stops the vent.
2	The 2nd Captain; assists 1, attends the apron, elevating screw, lock, and train tackle.
3	Loads, rams home, runs out, and trains.
4	Worms, sponges, rams home, runs out, and trains.
5	Gives shot and wad to 3, runs out, trains, and spans the breeching.
6	Gives sponge, rammer, and worm to 4, runs out, trains, and spans the breeching.
7 & 8	Run out, and attend handspikes.
9	Runs out, trains, and brings up shell.

Note.—With guns mounted on Rear chock carriages having side levers for running out, Nos. 7 and 8 will shift the side-tackles, and the left rear-man will attend roller handspike when necessary. With guns mounted on Hardy's carriages, the Exercise will be the same as above, except that No. 4 will attend compressor when the gun is *out*, and No. 8 when the gun is *in*.

men, 7 and 8; and with all Nos. above 11, 9 and 10. Assistant Handspikemen, 68-prs. and 10-inch guns, when Assistant Handspikemen will be 11 and 12. tionary Powderman is allotted to every gun on one side, and an extra powder- two guns.

Gun with 6 men. (*Both sides manned.*)

half-port; when the port is up, 1 provides stores, 2 casts off, and hooks on train- clear away and shift side-tackles, untoggle breeching, and span it when the gun word "Elevate," and withdraws the coin to allow 3 and 4 to put down the the gun is then run in, searched, loaded, and run out. With 7 men, 7 will upper half-ports are made to take off, 3 and 4 will take them off.

"*Fire,*" "*Stop the Vent,*" "Sponge," "Load," "Run out."

ORDERS FOR MANUAL EXERCISE.

On coming to the gun, Nos. 1 see the locks fixed and fit for use, vents clear, sights adjusted to the distance named, and the guns searched, loaded, and run out without further orders.

WORDS OF COMMAND.

"Prime."	"Ready."	"Sponge."
"Point."	"Fire."	"Load."
"Elevate."	"Stop the vent."	"Run out."

REMARKS ON THE DIFFERENT FIRINGS.

INDEPENDENT FIRING.

By this is meant, firing the guns independently of each other, each captain of a gun seizing the most favourable opportunity. This firing should always be used in action (unless ordered to the contrary) whenever the object is visible, the smoke from one gun not greatly impeding the fire of another.

(See Detail for Independent firing.)

FIRING IN SUCCESSION.

By this is meant, firing one gun after another in regular order, commencing from the foremost, or after gun, according as the wind is blowing from *aft*, or *forward*. This firing may be used with advantage, whenever a *continuous steady fire* is desired, as the smoke from one gun will not impede the firing of the next.

QUICK FIRING.

By this is meant, rapid independent firing, the tangent sight not being raised. This firing should be used when close alongside an enemy, as then but little pointing would be required.

(See Detail for Quick firing.)

BROADSIDE, AND DIVISIONAL FIRING.

By this is meant, firing the whole broadside, or a division of guns simultaneously, by order. Broadside firing should be used when the smoke hangs about the ship for some time, and divisional firing when the smoke clears away at shorter intervals, as then the fire would be more continuous. Broadside, or divisional firing could also be used with greater advantage within a moderate distance against stone forts than independent firing, from the increased concussion caused by a number of shot striking at the same moment. In divisional firing each deck, or the half of each deck, should be considered as a division according to circumstances.

CONCENTRATED FIRING.

By this is meant, firing guns previously laid by the aid of lines, or battens, so that the shot may cross each other at a given distance.

This firing would be most effective in case of smoke, or darkness, the object being visible from the upper deck, or mast head, and may be used at distances within, and beyond the point of concentration, but the latter must never exceed double that, at which the shot cross.

IN INDEPENDENT FIRING,

No. 1 raises the tangent sight according to the charge and distance named, lays the gun for the object, and gives the word "Ready" as soon as the elevation is correct, keeping the direction on with the handspikes, and taking care not to fire till the side-tackle falls are clear.

IN QUICK FIRING,

No. 1 sees the gun laid horizontal, and run out for the object, primes as the gun goes out, taking care not to cock the lock till the muzzle is clear of the port-sill, and not to fire till the side-tackle falls are out of hand.

The only words of command to be given are, "Run in," "Run out," and "Ready." 2 chalks the bed, and coin, and the guns are relaid whilst loading.

ARRANGEMENT FOR FIGHTING BOTH SIDES.

When necessary to fight both sides, the whole of the guns are to be manned, and worked with "Half crews" (as in casting loose); but if from casualties or other causes this is not practicable, the right guns should be left *in* after the first round, and the left guns manned and worked with whole crews.

NOTE.—In Action, or Exercise, the working with "half crews" should not be continued beyond 3 or 4 rounds, as after this, owing to casualties and the fatigue of working on this plan, the firing would be more efficiently kept up by working every other gun.

INSTRUCTIONS FOR A SIMULTANEOUS CONCENTRATED FIRE.

"*The lines should always be hooked on at the ports directly after casting loose.*"

The bearing, heel, and distance, having been given from the upper deck, the officers of the different divisions of guns will name the elevation, or depression to be given by marked coin (allowing for the distance and heel), together with the bearing, and then give the order, "Lay the guns;" on which the Nos. 1 are to give the orders for training, holding the lines *immediately under* the marks overhead, denoting the bearing, and the guns are to be trained till the sights are *parallel* to the lines: Nos. 1 then give the word "Elevate" and direct 2 to give the guns the required elevation, or depression, making the lines fast to hooks overhead; they then resume the trigger lines, and wait steadily for the orders "Ready," "Fire," which are to be *given by the officer* attending the director.

DISMOUNTING, AND MOUNTING.

DISMOUNT THE GUN. No. 1 gives the word "Run in," then "Elevate," takes out the coin, throws back depression chock, and sees the gun laid square between the housing-bolts; 2 prepares the train-tackle, hooks it to the runner, and lowers the gun; 3 and 4 pass the muzzle-lashing; 7 and 8 take out the keys, throw back the cap-squares, unhook the side tackles, and see the carriage clear; rear-men provide and hook the runner.

When the muzzle-lashing is passed, 1 gives the word "Dismount," and all the Nos. man the train-tackle, except 1, 3, 4, and the handspikemen; 3 and 4 remain at the muzzle-lashing until all parts bear an equal strain; handspikemen assist until of no further use, and then go to the train-tackle.

MOUNT THE GUN. Everything will be replaced by the same Nos.

NOTE.—When ordered to "*Dismount,*" No. 1 makes up the trigger-line round the lock, attends the coin to assist the handspikemen, leaves it on the bed ready for mounting, and when the gun is high enough, gives the order, "Well! Run the carriage back," he then replaces the depression chock.

REVOLVING GUN EXERCISE.

WITH A CREW OF 17 MEN, AND UPWARDS.

The crew are assembled as in the established gun exercise.

Gun Nos. 1, 2, 3, 4, 5, 6.

Auxiliaries, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, &c.

Traversing-tackle-men, 7, 8.

Handspikemen, 9, 10.

Assistant handspikemen, 11, 12.

Compressor-men, 13, 14.

Rear-men.—16, the right rear-man; 17, the left rear-man (*or the two highest Nos.*).

1. The Captain.	3. Loader.	5. Assistant Loader.
4. Sponger.	6. Assistant Sponger.	2. Second Captain.

PROVIDING STORES.

No. 1. Provides 3 vent-plugs, priming wire, tube-box, spare trigger-line, vent-bit, sees the lock fixed and fit for use, and places handspikes.

2. Assists 1.

3. Shot-grummet, spare breeching, wet swabs, wads, and fuze-wrench.

4. Shot-grummet, spare breeching, fire-bucket, and two stop handspikes.

5. Bearer, and shot.

6. Sponge, rammer, worm, and shot.

Stationary, and extra powdermen, two cartridge-cases, and two cartridges each.

NOTE.—Spare locks, and hammers are to be provided by the 2nd captain; axletrees, and trucks by 11 and 12.

Shells are always to be provided by the two highest Nos.

When pivot guns are mounted as broadside guns, and only *one* crew can be allotted to *two* guns, the "Stores" should be provided with "Both sides manned," as laid down in First Instruction.

EXERCISE WITH 17 MEN.

No. 1. The captain; commands, attends the breeching, primes, points, fires, and stops the vent.

2. The 2nd captain; assists 1, runs out, attends the apron, coin, lock, and rear-bolt.

3. Loads, rams home, runs out, attends fighting-bolt, shackles, and unshackles breeching.

4. Worms, sponges, rams home, runs out, attends stop-handspike, shackles, and unshackles breeching.

5. Brings up shot, or shell, runs out, traverses, and spans the breeching.

6. Gives sponge, rammer and worm to 4, runs out, traverses, and spans the breeching.

7 and 8. Run out, attend traversing-tackles, and shift side-tackles.

9, 10, 11, and 12. Run out, attend handspikes.

13 and 14. Run out, traverse, and attend compressors.

15. Runs out, and traverses.

16. Traverses, shifts traversing-tackle, attends stop-handspike and train-tackle.

17. Traverses, shifts traversing-tackle, brings up shot, or shell, and attends train-tackle.

NOTE.—These Nos. will be reduced for lighter, or increased for heavier guns, as may be necessary, when the rear-men will do the duties of 16 and 17. With less than 15 men, Nos. 11 and 12 will attend compressors.

When slide guns are fitted with Ferguson's Compressor, No. 8 is to attend it.

Stations for Casting Loose a Revolving Gun.

1 and 2 place handspikes, and provide stores; 3, 4, 5, and 6, provide stores, and clear away side-tackles; 7, 8, 16, and 17, clear away, and hook on traversing-tackles to fore part of slide; 9, 10, 11, and 12, clear away spans, and unscrew span shackle-bolts; 13, 14, 15, 16, and 17, clear away the ports and berthing. When the gun is clear, No 1 gives the word "Action on the fighting-bolt * * *" "Right (or Left), traverse," and when on the fighting-bolt *named*,* "Well," the gun is then searched, loaded, and run out. While the gun is being searched, the breeching should be shackled to the ship's *side.*

Stations for Casting loose a Broadside pivot Gun (both sides manned).

No. 1 places handspikes, and provides stores; 3 and 4 provide stores, and clear away side-tackles; 5 and 6 clear away spans, and unscrew span shackle-bolts; 2, 7, 8, and 9, clear away, and hook on traversing-tackles, and unship ports, and berthing. When the gun is clear, No. 1 gives the necessary orders for getting it on the fighting-bolt; the gun is then searched, loaded, and run out. While the gun is being searched, the breeching should be shackled to the ship's side.

WORDS OF COMMAND.

"Traverse."

"Prime."	"Ready."	"Sponge."
"Point."	"Fire."	"Load."
"Elevate."	"Stop the vent."	"Run out."

NOTE.—When the direction of the gun is to be altered, the word "Traverse" is to be given if the gun is *in*, and "Point" when the gun is *out*.

THE SERVICE CHARGES FOR THE FOLLOWING GUNS.

Nature of Gun.	Weight.	Length.	Charge.		
			Distant.	Full.	Reduced.
	cwt.	ft. in.	lb.	lb.	lb.
68-Pr.	95	10 0	16	12	8
10 Inch . . .	84	9 4	12	..	..
8 „ . . .	65	9 0 }	10	8	5
8 „ . . .	60	8 10 }			
8 „ . . .	52	8 0	..	8	5
8-Inch Carronade.	36	5 4	..	5	..
32-Pr.	56 & 58	9 6	10	8	6
32 „ A . . .	50	9 0	..	8	5
32 „ B . . .	45	8 6	..	7	5
32 „ C . . .	42	8 0	..	6	4
32 „ . . .	32	6 6	..	5	3
32 „ . . .	25	6 0	..	4	2½
32-Pr. Carronade .	17	4 0	..	2 lb. 10 oz.	..
(The charge of all other Carronades is also 1-12th the weight of their shot.)					
24-Pr. Howitzer .	12½	4 8	2½	..	..
12 „ . . .	10	4 6	2	..	..
12 „ . . .	6½	3 9	1¼	..	..

The 68-pr., and 32-pr. guns of 58, and 56 cwt. may be double-shotted as far as . . . . 400 yards.
The "A" and "B" ditto ditto . . . . 400 „
The "C" guns ditto ditto . . . . 300 „
The 32, and 25 cwt. 32-pr. guns, and 8-inch 65 and 60 cwt. guns 200 „

Carronades, the 8-inch 52 cwt. and the 10-inch guns, are never to be double-*shotted.*

Allowance for the Deflection of Shot occasioned by the Wind from a 32-pr. 56 cwt., charge 8 lb.

In firing with a moderate breeze (force 4) *across* the range, an allowance of 1 foot for every 100 yards of distance has been found a correct guide.

With a moderate gale (force 7) *across* the range, 2 feet for every 100 yards of distance. At 1000 yards' distance with the latter force of wind (7) *against* the range, $\frac{1}{4}^\circ$ more elevation should be given; and when *with* the range, $\frac{1}{8}^\circ$ less elevation, than in the Range Tables.

MORTAR EXERCISE.

13-Inch Sea-service Mortar.

Providing Stores.

No. 1. Provides tube box, and plummet.
,, 2. Sponge, sheepskin, and handspike.
,, 3. Shell hooks, and handspike.
,, 4. Traversing tackles, and priming wire.
,, 5. Trigger-line, and fuze implements.
,, 6. Cartridge case.

Exercise with 8 Men

(*in a Mortar Boat*).

No. 1. Commands, points, and primes.
,, 2. Sponges, wipes the bottom of the shell, uncaps the fuze, assists to put in shell, and traverses.
,, 3. Puts in cartridge, assists to put in shell, and traverses.
,, 4. Clears and serves the vent, pricks the cartridge, and traverses.
,, 5. Prepares fuzes, takes them to 8, traverses, and fires.
,, 6. Brings cartridge, and occasionally relieves 7.
,, 7. Prepares cartridges in the magazine.
,, 8. Prepares and hooks on shell in the hatchway.

Weight of mortar, 100 cwt. Extreme charge, 20 lb.
Weight of shell, 200 lb. Bursting charge, 10½ lb.

N.B.—Land service mortars are worked in a similar manner, the only difference being that handspikes are required for running up and training, and a shell beam, or shell hooks for bringing up the shell. They are trained for the object by bringing them on with pickets placed in the parapet for the purpose.

All mortars with the ordinary coin, are elevated at an angle of 45°; this elevation may be altered if necessary by putting in an additional coin, or, by substituting a smaller one for that commonly used.

Weight of 13-inch land service mortar,	36 cwt.	Extreme charge,	9 lb.
,, 10 ,, ,,	18 ,,	,,	4 ,,
,, 8 ,, ,,	8½ ,,	,,	2 ,,

INSTRUCTIONS FOR THE USE OF RED HOT SHOT.

1. Red hot shot are not, for the present, to be fired from any guns but 68 and 32-prs.; the charges used must not exceed $\frac{3}{4}$ of the heaviest charge allowed for the gun, as the expansion of the shot by being heated considerably decreases the windage, and consequently much increases the stress on the gun: thus the 56 cwt. 32-pr. gun, whose heaviest charge is 10 lb., should not be fired with a higher charge than 8 lb.: the charges for other guns must be likewise proportionably decreased.

2. To prevent accidents, every ship will be allowed a red hot shot gauge, through which the shot are to be passed before they are brought away from the furnaces: a red hot shot bearer will also be supplied, in which the shot are to be triced up, and then conveyed to the guns; but if these are not issued, the shot can be triced up in the ash buckets.

3. Shot can be readily made red hot in the furnaces of steam vessels, and to a moderate extent this can also be done in the copper holes of sailing ships; a 32-pr. shot will become red hot in the furnace of a steamer in about 15 minutes, and care must be taken that they are not heated *beyond a bright red*, as otherwise they are liable to fuze, and to become misshapen, and if so used they would be very liable to jam in the gun.

4. It is very dangerous to fire a shot when jammed in a gun, but a red hot shot may be rapidly cooled by water, which will cause it to contract, and the shot will then probably be easily removed from the gun; but if not, a small quantity of powder introduced down the vent, after the charge has been destroyed, will effect its removal with certainty.

5. Shot expand about $\frac{1}{63}$ part of their diameter when heated to a bright red; therefore, as the mean diameter of a 32-pr. shot, when so heated, is 6·273 inches, it is considered unsafe to fire red hot shot from either the 32 cwt. or the 25 cwt. 32-pr. guns or from the 32-pr. carronade, as the windage of those guns is very small.

6. Clean shot, and shot that pass readily through the cold shot gauges, should be used for firing when red hot; the shot must be scraped and cleaned to remove the scales and dirt, and then passed through the hot shot gauges, before they are sent up from below.

7. Whilst shot are being heated they should be turned, as the part resting on the furnace bars heats much more rapidly than the upper part; when the shot are heated to a *bright* red they must be removed from the furnaces whether they are wanted, or not.

8. Great care must be taken that the cartridges used are not in any way broken, or damaged. A number of dry and wet junk wads must be in readiness at the guns, also a number of wet grummet wads; these wads should be soaked in water for two or three hours beforehand, and then the water well pressed out of them, and care must be

taken that they are made small enough to fit easily in the guns when swelled by being soaked, otherwise the loading will be very difficult; the sponge should also be well damped, and water kept at the guns in case of accidents.

9. It has been found by experiment, that red hot shot do not burn more than the outer yarns of a well-soaked junk wad, even though left in the gun for a considerable period; and it has been also proved, that there is but little danger of the cartridge becoming ignited, even though quantities of smoke should come up through the vent; the grummet wad over the shot is necessary to prevent it from shifting in the bore from the motion of the vessel, or otherwise, and it should be well soaked to prevent it catching fire.

Precautions for loading guns with Red hot Shot.

First, the cartridge, then a dry junk wad, and then a wet junk wad are to be entered by No. 3; and 4 is to force them home together; it is recommended that this should be done with a damp sponge to insure any grains of powder being destroyed that may remain in the gun; No. 1 pricks the cartridge, and 4 withdraws and returns the sponge.

The shot is then to be brought up to the left of the gun, and entered by 3 and 4; the gun should be laid with sufficient elevation to allow the shot to roll home of itself; 3 then places a wet grummet wad over the shot, and 4 receives the rammer, forces it home, and assisted by 3, gives it two smart blows to insure the shot being close nome.

After the loading is completed, the gun is to be run out, trained and elevated for the object in precisely the same manner as when firing cold shot; but the sooner the gun is fired the better, as the shot not only cools very rapidly when in the gun, but it is believed that it has a tendency to become misshapen from cooling unequally. It is further recommended, when firing red hot shot, to select those guns that may be the nearest to the engine room hatchway, and not to fire them indiscriminately from all guns.

Exercise for Heavy Rifled Guns, mounted on Slides, with a Crew of 14 Men at the 7-inch M.L. and 15 at the 8-inch and 9-inch Guns.

Preliminary Drill.

Call for action. At the "Call for action," the stationary powdermen repair to the magazine scuttle for a cartridge each, and then return to their places in the rear of their guns amidships, ready to receive all further supply of powder from the extra powdermen.

The guns are to be loaded with full charges and shell, and run out; but are on no account to be fired without distinct orders from the upper deck.

Note.—Should the Commanding Officer wish to load with any charge or projectile other than the above-mentioned, he will communicate his orders by means of the voice tubes, and the "Attention" call of the bugle.

The call for action preceded by one "G" is for exercise, the same as for action, but without powder; and when by two "G's," for inspection.

A roll of the drum will correspond with one "G" on the bugle.

Position of Nos. when closed up. No. 1, the captain, on the slide, facing the port.

2, the second captain, on the right of 1, clear of the recoil.

3, the loader and clampman, close to the ship's side, on the left.

4, the sponger and clampman, close to the ship's side, on the right.

5, the assistant loader, in rear of 3.

6, the assistant sponger, in rear of 4; and so on.

7 and 8, compressor and training tackle men.

9 and 10, levermen.

The two highest Nos. rearmen.

Note.—The Nos., except 1 and 2, stand quarter-face to the gun. When desirable, for drill purposes, to change duties, at the order "Change rounds" No. 3 becomes 4, and the remaining Nos. move round one place to the left.

Number. No. 1 to the highest No.

The Nos. are responsible for the following stores. No. 1, 3 vent plugs, priming wire, vent bit, and spare trigger-line.

2, levers and tubes.

3, spare breeching, wet swab, wads, and shell burton.

4, sponge, rammer, worm, and fire bucket.

5 and 6, bearers, shot, and grummet.

Stationary and extra powdermen, one cartridge each.

Note.—With 8-in. and 9-in. guns, 11 and 12 are responsible for winch handles.
With revolving and chase guns, 4 supplies two stop handspikes.

DUTIES IN CASTING LOOSE WHEN SECURED INBOARD.

Nos. 1 and 2 pass the levers to 3 and 4, who bear out, and 2, 9, 10, 11, and 12 trice up the port.

3 and 4 cast off the muzzle-lashing.

5 and 6 provide shot.

7 and 8 clear away training tackles.

9 and 10 clear away breast frapping and side tackles, and ship levers.

11 and 12 ship winch handles, and provide shot.

Rearmen assist 7 and 8 in hooking training tackles, and attend preventor ropes.

No. 1 gives the word "Elevate," sees the gun laid square, searched, loaded, and run out.

2 coils up the lashings.

When the gun is out, 2 takes up the rear, 3 the front flap.

NOTE.—Rearmen screw in "Train bolts," and hook outer blocks of training tackles.

In casting loose from the housing position, it will generally be unnecessary to run slide guns in, as they are already in position for loading.

With upper deck guns, the Nos. above 8, having completed their respective duties, clear away ports and berthing.

PRIME.

No. 1 places the tube in the vent and half-cocks.

POINT.

No. 1 adjusts the sight, gets on the direction of the object, and then retires to the extent of the trigger-line.

Levermen ship levers for training.

The remaining Nos., except 2, 3 and 4, man the training tackles.

NOTE.—The position of Nos. on training tackles will be—

Preventor Ropemen outside; remaining Nos. inside.

Training Winchmen 5, 7, 11, and 13.

ELEVATE.

The lever, and clamp men lay the gun under the direction of No. 1.

NOTE.—The Levermen return to the pointing position after the clamps are set up.

When laying the gun by "Wood scale," 2 attends it; when elevating with the gun *in*, 11 and 12 attend the clamps.

When the sight requires alteration or heel of the ship changes, 1 will give the word "Elevate," and 2 will "Half-cock."

When firing with more elevation than the port will allow, a quoin will have to be used, as the clamps *must* be left slackened. When the elevation is likely to remain unaltered, the drum should be chalked. When necessary, the elevation required for loading should be given directly the gun is in.

READY.

No. 2 cocks the gun, levermen unship levers, rearmen attend preventor rope.

NOTE.—When necessary to train the gun after the word "Ready," the levers will be used, and withdrawn immediately the word "Well" is given.

FIRE. No. 1 fires with a suitable jerk.

NOTE.—When the gun has recoiled, Levermen ship the levers for running in; 7 and 8 hitch the training tackles.

RUN IN. No. 1 makes up the trigger-line; all the Nos. then man the preventor rope, except 1 and 2, who attend levers.

NOTE.—When necessary, 3 and 4 attend side tackles, and 7 and 8 compressors.
When running in, one part of the preventor rope only is to be manned.
When the ship is rolling, the Levermen should ease up the levers quickly when required.
When the gun is in, No. 1 holds up his hand; Rearmen secure preventor rope; Compressor-men set up compressors.
When running in with winches, 9, 10, 11, and 12 man the winches, 7 and 8 attend nipping levers; 4 attends the tripper.

SPONGE. No. 1 puts in a vent plug, 3 and 4 step inside the breeching together; 6 gives the sponge to 4, who, assisted by 3, forces it hard home to the bottom of the bore, giving it a round turn; he then withdraws it and 6 gets the rammer.

NOTE.—No. 6 will give the rammer before returning the sponge. Should fire be observed on the sponge, or in the bore, the gun is not to be loaded until it has been completely extinguished.
While the gun is being sponged, 5 and 13 bring up the projectile.
When the rope sponge is used, 6 holds it with the sponge in his right hand and rammer in his left. On the sponge being withdrawn by 4, 6 passes the rammer on his left, and behind him, so as to hold it in his right hand ready for loading.

LOAD. The powderman gives the cartridge to 3, who enters it to the full extent of his arm; 4 rams it home.
5 and 13 place the projectile on the slide, 3 and 4 enter it and ram home.
4 springs the rammer, 6 returns it, 3 and 4 step out.

NOTE.—When the rammer is withdrawn, 1 pricks the cartridge.
With heavy guns, 5 hooks the burton to the bearer, and attends the guy; 7, 9, 11, and 13 trice up the projectile, when slung; 3 steadies the shot after sponging.
The mark on the rammer staff will indicate when the full charge and common shell are home; and allowance is to be made when other charges are used.
Whilst the gun is in, 2 hooks on a tube; when necessary, 3 shifts the shell burton.

RUN OUT. All the Nos. run the gun out by the side tackles, except 1, 2, and rearmen, who attend lever and preventor ropes.

NOTE.—7 and 8 man the falls on the inside, and attend the compressors.
When the gun is out, 5 and 6 coil down the side-tackle falls. It will frequently occur that the side tackles need not be used. In running out, care

should be taken to prevent the carriage from striking heavily against the buffers, as the projectile is thereby liable to be displaced; and the levers should be attended as in running in.

The preventor ropes are *always* to be eased with a turn round the bollards.

WOODEN SIDE TANGENT SCALE.

INSTRUCTIONS FOR ADJUSTING THE WOODEN SIDE TANGENT SCALES TO GUNS, AND FOR THEIR USE.

The gun, when on its carriage, and run out in its place in the ship, is to be laid perfectly horizontal, and the foot of the scale is then to be shortened (if necessary), so that, when held, and resting in a perpendicular position on the step of the bracket, the line of the Zero, or O, is brought into coincidence with the line of the quarter sight.

Previous to using the tangent scale, it will be necessary to observe the degree of the heel, or inclination of the ship, by means of the pendulum supplied with the scales, and an elevation, or depression is to be given to the gun to the amount shown, in order to bring it to the horizontal position; and the degree of elevation, required for the estimated distance from the object to be fired at, is to be reckoned from the point on the scale then opposite to the quarter sight.

NOTE.—The gun is to be laid horizontally by means of the spirit level, or by common level with plumb line, laid from back to front sight.

RANGES WITH SEA-SERVICE IRON ORDNANCE, OBTAINED ON BOARD HER MAJESTY'S SHIP "EXCELLENT."
Elevation by Tangent-sight.

Nature of Gun.	Length.	Weight.	Diameter of Bore.	Windage.	Weight of Shot or Shell.	Charge.	The Elevation, and Range in Yards, with corresponding Times of Flight.																		
							¼	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14
	ft. in.	cwt.	in.	in.	lb.	lb.																			
10-In.	9 4	86	10·	·16	{Shot / Shell} 84	12	140	260	380	500	650	800	950	1100	1400	1600	1780	1940	2100	2240	2380	2520	2660	2800	2930
								¾"		1⅓"	2¼"	3"	3¼"	4"	4¾"	5¾"	6¾"	7¼"	8¼"	9"	9¾"	10¾"	11½"	12¼"	13"
8-In.	{9 0 / 8 10}	{65 / 60}	8·05	·125	Shot 56	10	160	300	430	550	750	900	1050	1200	1500	1760	1980	2160	2340	2520	2700	2850	3000	3120	3240
,,	,,	,,	,,	,,	Shell 51	10	200	350	480	600	800	950	1100	1240	1500	1760	1980	2160	2340	2500	2660	2780	2990	3000	3100
								1"	1½"	2"	2½"	3"	3½"	4¼"	5¼"	6¼"	7¼"	8¼"	9¼"	10"	10¾"	11½"	12¼"	13"	13½"
8-In.	{9 0 / 8 10 / 8 0}	{65 / 60 / 54}	8·05	·125	Shot 56	8	140	260	380	500	680	830	980	1130	1430	1660	1880	2060	2240	2420	2600	2760	2900		
,,	,,	,,	,,	,,	Shell 51	8	150	300	430	550	730	880	1020	1160	1430	1660	1880	2060	2240	2400	2560	2680	2780		
								1"	1¼"	2"	2½"	3"	3½"	4"	5"	6"	7"	8"	9"	9¾"	10½"	11¼"	12"		
68-Pr.	10 0	95	8·12	·198	Shot 68	16	220	340	500	640	860	1060	1240	1400	1700	1960	2180	2380	2560	2720	2880	3040	3200	3340	3480
								½"	1"	1¼"	2¼"	3"	3¾"	4¼"	5¼"	6¼"	7¼"	8¼"	9¼"	10¼"	11⅛"	12"	12⅞"	13¾"	14⅝"
,,	,,	,,	,,	,,	Shot 68	12	200	300	400	510	730	940	1160	1330	1590	1830	2060	2270	2470	2640	2790	2940	3070	3200	3330
,,	,,	,,	,,	,,	Shell 51	12	400	510	620	730	930	1090	1230	1340	1560	1770	1970	2170	2360	2530	2690	2850	2990	3130	3260
							1"	1½"	1¾"	2"	2¾	3¼"	3¾"	4"	5"	6"	7"	8"	9"	10"	11"	12"	13"	14"	15"
32-Pr.	9 6	58	6·375	·198	Shot 32	10	320	460	600	720	930	1140	1320	1500	1740	1980	2200	2380	2560	2720	2880	3020			
,,	,,	,,	,,	,,	Shell 24	10	440	600	710	820	1000	1140	1280	1400	1630	1840	2030	2200	2360	2500	2640	2770	2880		
							1⅛"	1¼"	1¾"	2"	2¾"	3⅛"	3½"	4¼"	5½"	6½"	7¼"	8¼"	9"	9¾"	10¾"	12"	14"		

NOTE.—It is better, as a rule, not to fire 6-inch Shells with a higher charge than 8 lb., as, when fired with 10 lb. charges, they sometimes burst prematurely. In firing Spherical Case from heavy guns, the Charges, Elevations, and Times of Flight may be taken as for Common Shell.

RANGES WITH SEA-SERVICE IRON ORDNANCE, OBTAINED ON BOARD HER MAJESTY'S SHIP "EXCELLENT."
Elevation by Tangent-sight.

Nature of Gun.	Length.	Weight.	Diameter of Bore.	Windage.	Weight of Shot, or Shell.	Charge.	The Elevation, and Range in Yards, with corresponding Times of Flight.																		
							¼	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14
	ft. in.	cwt.	in.	in.	lb.	lb.																			
32-Pr.	9 6	56	6·41	·233	Shot 32	10	300	440	570	700	900	1100	1280	1460	1700	1900	2100	2280	2460	2620	2780	2920	3060	3180	3300
,,	,,	,,	,,	,,	Shell 24	10	430 1⅛″	570 1½″	700 1¾″	800 2″	960 2½″	1100 3″	1230 3½″	1350 4″	1570 5″	1760 6″	1940 7″	2100 7¾″	2250 8½″	2400 9¼″	2530 10″	2660 11″	2780 12″	2880 13″	2970 14″
,,	,,	,,	,,	,,	Shot 32	8	250	380	500	600	800	1000	1200	1380	1620	1820	2020	2200	2340	2480	2620	2760	2900		
,,	,,	,,	,,	,,	Shell 24	8	350 1″	500 1½″	620 1¾″	720 2″	880 2¼″	1040 3″	1180 3½″	1320 4″	1520 5″	1720 6″	1920 7″	2080 7¾″	2220 8½″	2360 9¼″	2500 10″	2620 11″	2740 12″	2840 13″	2940 14″
32-Pr. (A)	9 0	50	6·375	·198	Shot 32	8	300	440	580	700	900	1100	1280	1460	1680	1900	2100	2280	2460	2620	2780				
,,	,,	,,	,,	,,	Shell 24	8	380 1″	520 1¼″	640 1⅝″	740 1⅞″	910 2¼″	1070 3″	1220 3½″	1340 4¼″	1580 5½″	1790 6½″	1970 7¼″	2140 8¼″	2310 9″	2470 10″	2620 11¼″				
32-Pr. (B)	8 6	45	6·35	·173	Shot 32	7	260	400	520	640	840	1020	1200	1380	1600	1820	2020	2200	2360	2520	2680				
,,	,,	,,	,,	,,	Shell 24	7	300 ¾″	460 1½″	600 1½″	700 1¾″	860 2½″	1020 2¾″	1180 3¾″	1300 4¾″	1500 5¼″	1700 6¼″									
32-Pr. (C)	8 0	42	6·35	·173	Shot 32	6	240	360	480	600	800	960	1120	1280	1500	1700	1880	2060	2240	2420	2580				
,,	,,	,,	,,	,,	Shell 24	6	200	360 1½″	500 1½″	600 1¾″	800 2¼″	960 2¾″	1120 3½″	1240 4¾″	1460 5¼″	1660 6¼″									

NOTE.—It is better, as a rule, not to fire 6-inch Shells with a higher charge than 8 lb., as, when fired with 10 lb. charges, they sometimes burst prematurely. In firing Spherical Case from heavy guns, the Charges, Elevations, and Times of Flight may be taken as for Common Shell.

RANGES WITH BRASS ORDNANCE. Elevation by Tangent-sight.

Nature of Gun.	Diameter of Bore.	Windage.	Weight of Shot, or Spherical Case.	Charge.	Elevation, and Range in Yards, with corresponding Lengths of Fuze.												
Howitzer. 24-Pr. 4 ft. 8 in. 12¼ cwt.	in. 5·72	in. ·12	Sph. Case, 20 lb. No. of Balls, 100	lb. 2½ Burster, 3 oz.	¼°	½°	¾°	1°	1½°	2°	2½°	3°	3½°	4°	4½°	5°	6°
					250	300	350	400	500	600	700	800	900	1000	1100	1200	1350
					..	·1	·1	·15	·2	·25	·35	·45	·55	·65	·75	·85	1·0
					These Ranges may also be used for the Hollow Shot, and Shell.												
Howitzer. 12-Pr. 4 ft. 6 in. 10 cwt.	4·58	·12	Shot. 12 lb.	2 lb. Burster, 1 oz. 12 drs.	⅝°	⅞°	1⅛°	1½°	2°	2½°	3°	3½°	4°	4½°	5°	6°	7°
					200	300	400	500	650	800	950	1050	1150	1250	1350	1550	1700
					·1	·15	·2	·25	·35	·5	·6	·7	·8	·9	1·0		
					These Ranges may also be used for the Spherical Case, and Common Shell.												
Howitzer. 12-Pr. 3 ft. 9 in. 6¼ cwt.	4·58	·12	Sph. Case, 10 lb. No. of Balls, 75	1¼ lb. Burster, 1 oz. 12 drs.	½°	¾°	1°	1½°	2°	2⅜°	3°	3⅜°	3¾°	4⅛°	4½°	5°	6°
					250	300	350	450	550	650	700	750	800	850	900	950	1050
					·1	·1	·15	·2	·3	·4	·45	·5	·6	·6	·65	·7	·8
					These Ranges may also be used for the Hollow Shot, and Shell.												
Gun. 6-Pr. 5 ft. 6 cwt.	3·67	·12	Sph. Case, 5 lb. No. of Balls, 30	1¼ lb. Burster, 12 drs.	¼°	½°	¾°	1°	1½°	2°	2½°	3°	3½°	4½°	5½°	6°	
					300	400	500	600	700	800	900	1000	1100	1200	1300	1400	
					·1	·15	·2	·25	·3	·4	·5	·6	·7	·8	·9	1·0	
					These Ranges may also be used for the Shot.												

NOTE.—In firing Spherical Case from heavy guns, the Charges, Elevations, and Times of Flight may be taken as for Common Shell.

ARMSTRONG GUNS.

SEA SERVICE.

Extracted by permission of the Lords Commissioners of the Admiralty.)

Armstrong Gun Instruction.

PARTS OF THE GUN.

Bore.—A wrought-iron many-grooved rifle barrel.

Chamber.—The portion of the interior of the gun extending from the forepart of the slot to the commencement of rifling, of greater diameter than the bore, in order to receive easily the projectile, and cartridge.

Breech.—The portion of the gun, extending from the forepart of the slot to the rear.

Breech Screw.—A cylinder of iron with a screw turned on the outside, working in a female screw in the breech, presses the vent piece into its place when the gun is loaded.

Vent Piece.—A plug of steel or wrought iron, containing the vent: this plug when in the slot forms the bottom of the chamber, and is firmly fixed in its place by the action of the breech screw.

A conical ring (generally copper), on the front face of the vent piece, corresponds to a conical copper ring at the end of the chamber.

Breech Lever.—A weighted arm on the end of the breech screw.

Cams.—Four projections, two on the breech screw, and two on the lever, to enable the latter to be used as a hammer.

Tangent Ring.—A ring of brass on the rear end of the breech, forming a socket to contain the—

Tangent Sight, furnished with a moveable sight for giving deflection.

Trunnion Sight.—A dispart on the trunnion.

POINTS TO BE PARTICULARLY ATTENDED TO IN ORDER THAT THE GUN, ETC., MAY BE PRESERVED IN PROPER WORKING ORDER.

Breech Screw, and Bore.—The breech screw, to be thoroughly cleaned and oiled after firing, the bore to be kept carefully greased to prevent rust.

Elevating Screw, &c.—This screw should not be removed from the bed oftener than is absolutely necessary, no attempt should be made to keep it bright, and it must never be cleaned with emery, brick dust, or other material of a like description. The occasional application of a little oil will be sufficient to preserve it in working order. If these precautions are not attended to, it is liable to work loose, and greatly interfere with the correct laying of the gun. When the elevating screw is worked with a ratchet and lever, care must be taken that the collar of the ratchet be kept well oiled and in perfect order, so that when disengaged from the ratchet, it may move round freely without in any way affecting the elevating screw.

Surfacing.—Tools are supplied for facing the copper rings of the

breech, and vent piece; the surfacing should be performed after every 100 rounds, or oftener if necessary.

The gun, however, will not be injured should this operation be neglected.

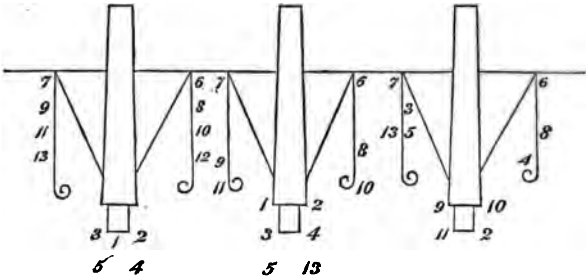
Note.—The best machinery oil should be used for the screw and working parts of the gun.

Changing Rounds.

No. 1	becomes	5		No. 7	becomes	6
,, 5	,,	3		,, 6	,,	8
,, 3	,,	13		,, 8	,,	10
,, 13	,,	11		,, 10	,,	12
,, 11	,,	9		,, 12	,,	4
,, 9	,,	7		,, 4	,,	2
				,, 2	,,	1

Positions.

Attention. Running out, and Loading. Pointing.



Pr. Boy. 12 1 12

MANNING BOTH SIDES.

"Man both sides." { Each watch will repair to its respective side, the odd numbers standing to the left of the left guns; even numbers to the right of the right guns.

Left guns—				Right guns—		
3	becomes	2		4	becomes	2
5	,,	3		6	,,	3
7	,,	4		8	,,	4
9	,,	5		10	,,	5
11	,,	6		12	,,	6
&c.	,,	&c.		&c.		&c.
1	remains	1		2	,,	1

PROVIDING STORES (*both Sides manned*).

No. 1 provides tube box, vent bit, spare trigger line, tangent sight, *and places* handspikes.

No. 2, vent piece, spare breeching, and fuze wrench.

No. 3, sponge, rammer, lubricating wads, shot, and grummet.

Stationary and extra powder boys, two cartridge cases, and two cartridges each.

Note.—With heavy guns, 3 provides a bearer, and 2 assists in providing shot. The shot are placed in a grummet or rack in rear of the gun.

"Man the Starboard or Port Guns."

Exercise with 13 Men to an Armstrong Gun.

Mounted as a Broadside Gun.

No. 1. The Captain, commands, attends the breech, primes, points, and fires.

2. The 2nd Captain, assists 1, attends vent piece, runs out, attends coin or elevating screw, lock, and handspike.

3 attends vent piece, runs out, and trains.

4 runs out, loads, sets the fuze under the direction of 1, and trains.

5 runs out, sponges, rams home, and trains.

6, 7, and 8 run out, and train.

9 and 10 run out, and attend handspikes.

11 runs out, and attends handspike.

12 runs out, and trains, or (if necessary) attends train tackle.

13 brings up lubricating wad, shot or shell, and trains.

Note.—With light guns, 2 attends the vent piece, 3 sponges, and 4 loads. With heavy guns, 2 assists 1 with the breech lever, 3 and 4 attend the vent piece, 5 and 6 sponge, and load.

N.B.—The preceding duties, and the following drill, will answer for every description of Armstrong guns; the various complements of men, and the difference in the carriages on which they may be mounted, requiring some slight modifications.

Words of Command. Sponge. Load. Cartridge. Home. Prime. Point. Elevate. Ready. Fire. Run out. Run in.

ARRANGEMENT FOR FIGHTING BOTH SIDES.

When necessary to fight both sides, the whole of the guns are to be manned with half crews, and worked with the reduced complements on precisely the same principle as that laid down for the full guns' crews; but when from casualties or other causes this is not practicable, then the right guns should be left in after the first round, and the left guns manned and worked with whole crews.

Revolving Gun Exercise, with a crew of 17 Men to a 100-pr. Armstrong Gun.

The crew are assembled, and stationed as for a broadside Armstrong gun.

Guns	No. 1 to 6
Auxiliaries	7 „ 17
Traversing tacklemen	7 and 8
Handspikemen	9 „ 10
Assistant Handspikemen	11 „ 12
Compressor men	13 „ 14

Rearmen, 16 the right rear man and 17 the left rear man *(or the two highest numbers)*.

Providing Stores.

No. 1 provides tube box, vent bit, spare trigger line, tangent sight, and places handspikes.

2, vent piece, and assists 1.

3, lubricating wads, tin cups, shot grummet, and spare breeching.

4, shot grummet, spare breeching, fire bucket, and two stop handspikes.

5, sponge, rammer, and shot.

6, fuze wrench, bearer, and shot.

Stationary and extra powder boys, two cartridge cases and two cartridges each.

Note.—When pivot guns are mounted as broadside guns and only one crew can be allotted for two guns, both sides are manned, and the stores provided as laid down in the exercise for a broadside gun.

In order to avoid injury to the sights of upper-deck guns, from the working of ropes, &c., they are not to be kept shipped, except when actually required for use, but should be placed inside the bracket of the carriage, in staples or sockets fitted to receive them.

Exercise with 17 Men.

No. 1, the Captain, commands, attends the breech, primes, points, and fires.

2, the Second Captain, assists 1, attends the breech, coin or elevating screw, lock, and rear bolt.

3, traverses, attends vent piece, and fighting bolt.

4, traverses, attends vent piece, and stop handspike.

5, traverses, sponges, enters shot or shell, and rams home.

6, traverses, sponges, enters shot or shell, and cartridge, sets the fuze under the direction of 1, and rams home.

7 and 8, run out, attend traversing tackles, and shift side tackles.

9 to 12, run out, and attend handspikes.

13 and 14, run out, traverse, and attend compressors.

15, runs out, and traverses.

16, runs out, traverses, shifts traversing tackles, brings up shot or shell, attends stop handspike, and train whip.

17, runs out, traverses, shifts traversing tackles, brings up shot or shell, and attends train whip.

Note.—If necessary, all the numbers assist in running out.

The crew will be reduced for lighter, or increased for heavier guns, as may be necessary, when the rear men will do the duties of 16 and 17; with less than 15 men, the assistant handspikemen will attend the compressors; and with less than 14 men, 2 will be the right assistant handspikemen.

When the inside compressor is used, 7 and 8 will attend it on their respective sides.

PROJECTILES.

For the 100, 40, and 20-pr. Guns.

Three descriptions, viz., *Solid Shot*, *Common*, and *Segment Shell*.

Solid shot, of wrought, or cast iron, with either a flat, or conical head.

Common shell, of cast iron, with a cavity sufficient to contain a large bursting charge; the head is conical and fitted with a female screw which receives the plug or fuze.

Segment shell, the 100-pr., contains 112 cylindro segments of cast iron, the 40-pr. 64, and the 20-pr. 78; in the centre is a cavity sufficient to contain the bursting charge, &c.; the head is conical, fitted with a female screw which receives the plug or fuze.

For the 12, and 6-pr. Guns.

Only one description for these guns, viz., Segment shell, which is of the same construction as that for the heavier guns, but contains only 49 segments.

FUZES.

For the 7-inch, and 40-pr. Guns.

Two descriptions, viz., *Time* and *Pillar*.

Time fuze is of gun metal, the parts kept firmly together by a cap, which must be loosened in order to adjust the fuze; round the centre runs a band of pressed mealed powder, covered with varnished paper, marked in inches, and tenths.

To adjust the fuze, loosen the cap with the fuze wrench, then turn the metal collar round till the arrow marked on it corresponds with the length of fuze required, then tauten the cap by hand, after which screw it firmly down with the fuze wrench. The portion of the scale left blank, covers metal, and when the fuze is not required, the arrow on the collar should always be set on this metal. When the time fuze is set to zero, the shell will burst immediately on leaving the muzzle; it is therefore thus set when it is intended to use a projectile as case.

Note.—The fuzes are not to be screwed into the shell till required for use. The female screw in the head of the 7-inch, and 40-pr. shell, is of the G. S. gauge, the tap of the time fuze is of a less gauge, consequently a hollow metal socket (called an adapter) is supplied, fitted with a male screw on the outside of the Moorsom gauge, and on the inside with a female screw of the gauge of the time fuze; this socket being screwed into the head of the shell, receives the time fuze.

It is in contemplation to have the fuze holes of one gauge for all shell.

Pillar fuze.—This fuze is intended to explode the shell on striking the object; it is screwed into the head of the shell and requires no fitting. The tap of this fuze being of the Moorsom gauge, no adapter is required.

For the 20, 12, and 6-pr. Guns.

Two descriptions, viz., Time, and Percussion.

Time fuze, the same as that used for the heavier descriptions of Armstrong guns.

Percussion fuze.—This fuze is intended to explode the shell on striking or grazing; it is placed in the shell immediately above the bursting charge, a plug or time fuze, fitted for the required distance, being screwed into the point of the shell.

Note.—The percussion fuze is only intended for the segment shell; it may be used either by itself or in combination with the time fuze; but when using the time fuze with the segment shell, the concussion fuze must always be used in combination with it.

BURSTING CHARGES FOR THE VARIOUS DESCRIPTIONS OF SHELL.

Vide Table, p. 209.

	100-Pr.	40-Pr.	20-Pr.	12-Pr.
Common Shell . . .	8 lbs. L G	$2\frac{1}{2}$ lbs. L G	1 lb. F G	..
Segment Shell . . .	3 lbs. L G	10 oz. L G	$1\frac{5}{16}$ oz. F G	$\frac{9\frac{1}{4}}{16}$ oz.

All common shell and the segment shell for the 100, and 40-prs. are loaded in the ordinary manner, the bursting charges being composed of loose powder.

The bursting charge for the 20, 12, and 6-prs., segment shell, is contained in an iron cylinder; this is slipped into the shell, and when the shell is not required for use, it is kept in its place by a wooden plug covered with serge; when the shell is required for immediate service, the wooden plug is removed and the percussion fuze takes its place.

Note.—When using shells with loose bursting charges, care must be taken that they are completely filled with powder, otherwise they will be very liable to burst in the gun, and may thus very probably injure the rifling.

LENGTH, ETC., OF THE VARIOUS DESCRIPTIONS OF ARMSTRONG GUNS.

Nature of Gun.	100-Pr.	40-Pr.	20-Pr. (sea-service).	12-Pr. (sea service).	6-Pr.
Weight complete	82 cwt.	32 cwt.	13 cwt.	cwt. qr. lbs. 8 0 24	3 cwt.
Length . . .	10 ft.	10 ft.	$5\frac{1}{2}$ ft.	5 ft. 10 in.	5 ft.
Calibre . . .	7 in.	4·75 in.	3·75 in.	3 in.	2·5 in.
Twist of Rifling	One turn in 37 calibres.	One turn in 37 calibres.	One turn in 38 calibres.	One turn in 38 calibres.	One turn in 30 calibres.

Length of gun is measured from muzzle to rear of breech, not including the breech screw.

EXERCISE FOR THE ARMSTRONG 12-PR. MOUNTED AS A FIELD GUN.

The detachment fall in, two deep, in close order; 1 tells them off from the right, 2 being the right hand man of the rear rank, 3 the right hand man of the front rank, 4 the second man from the right in the rear rank, 5 the man in his front, and so on.

Rear rank, 2, 4, 6, 8, 10, 12, 14.

Front rank, 1, 3, 5, 7, 9, 11, 13, 15.

POSTS, AND DUTIES WITH 15 MEN.

No. 1, between the breech and right wheel, points, and commands.

2, between the breech and left wheel, attends breech screw, and vent piece, primes, and fires.

3, one yard in rear of the right wheel, attends handspike, and loads.

4, one yard in rear of left wheel, sponges, and rams home.

5, five yards in rear of right wheel, serves ammunition to 3.

6, ten yards in rear of 5, serves ammunition to 5.

7, in rear of limber, serves ammunition to 6.

8, in rear of limber, assists 7.

9, in the shafts.

10, 12, 14, with the right drag rope.

11, 13, 15, with the left drag rope.

Words of command. Action. Load. Cartridge. Home. Ready. Fire.

CHANGING ROUNDS.

1	becomes	3	14	becomes	9
3	,,	5	9	,,	7
5	,,	15	7	,,	8
15	,,	13	8	,,	6
13	,,	11	6	,,	4
11	,,	10	4	,,	2
10	,,	12	2	,,	1
12	,,	14	Round the front.		

20-PR. ARMSTRONG FIELD GUN.

The drill for this Gun, with the exception of dismounting, will be precisely similar to that for the 12-pr., the additional men being on the drag ropes.

RANGES FOR ARMSTRONG'S SHORT 20-PR., 12½ cwt.

25 lbs. Projectiles. Charge, 2 lbs. 8 oz.
21 lbs. Projectiles. Charge, 2 lbs. 10 oz.

Elevation by Tangent Sight.

Projectile.	Elevation.	0° 15′	0° 30′	1° 0′	1° 30′	2° 0′	2° 30′	3° 0′	3° 30′	4° 0′	4° 30′	5° 0′	6° 0′	7° 0′	8° 0′	9° 0′	10° 0′
		yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.
25 lbs. . .	Range	150	245	400	530	650	780	920	1050	1170	1300	1420	1670	1910	2150	2370	2580
21 lbs. . .	Range	150	250	410	550	690	830	960	1090	1220	1350	1480	1740	1980	2230	2450	2680

The above Ranges will answer for 20-Pr., Common and Segment Shell.

RANGES FOR ARMSTRONG'S 12-PR., 8½ cwt.

Weight of Shell 11 lb. 12 oz., complete; charge, 1½ lb.

Elevation by Tangent Sight.

Range .	yds. 100	yds. 200	yds. 300	yds. 400	yds. 500	yds. 600	yds. 700	yds. 800	yds. 900	yds. 1000	yds. 1100	yds. 1200	yds. 1300	yds. 1400	yds. 1500
Elevation .	0° 7′	0° 14′	0° 23′	0° 33′	0° 44′	0° 56′	1° 10′	1° 24′	1° 38′	1° 53′	2° 8′	2° 25′	° 42′	3° 0′	3° 20′
Range . .	yds. 1600	yds. 1700	yds. 1800	yds. 1900	yds. 2000	yds. 2100	yds. 2200	yds. 2300	yds. 2400	yds. 2500	yds. 2600	yds. 2700	yds. 2800	yds. 2900	yds. 3000
Elevation .	3° 40′	4° 0′	4° 21′	4° 42′	5° 4′	5° 26′	5° 47′	6° 9′	6° 30′	6° 53′	7° 16′	7° 40′	8° 5′	8° 30′	8° 56′

APPROXIMATE MEAN RANGES FOR ARMSTRONG'S 100-PR., Weight 81 cwt., charge 12 lb.
Common Shell, Weight 104 lbs. 8 oz.; Segment Shell, Weight 101 lbs.
Elevation by Tangent Sight.

Elevation	0° 15′	0° 30′	1° 0′	1° 30′	2° 0′	2° 30′	3° 0′	3° 30′	4° 0′	4° 30′	5° 0′	5° 30′	6° 0′
Common Shell. Range	yds. 190	yds. 320	yds. 530	yds. 750	yds. 920	yds. 1100	yds. 1270	yds. 1450	yds. 1620	yds. 1800	yds. 1970	yds. 2140	yds. 2300
Segment Shell. Range	170	300	510	700	870	1040	1200	1360	1520	1670	1830	1980	2120

Elevation . . .	6° 30′	7° 0′	8° 0′	9° 0′	10° 0′	11° 0′	12° 0′	13° 0′	14° 0′	15° 0′	16° 0′	17° 0′	18° 0′
Common Shell. Range	yds. 2450	yds. 2610	yds. 2920	yds. 3190	yds. 3470	yds. 3740	yds. 4000	yds. 4250	yds. 4500	yds. 4730	yds. 4950	yds. 5150	yds. 5350
Segment Shell. Range	2260	2400	2670	2930	3190	3440	3650						

RANGES FOR ARMSTRONG'S 40-PR. 32½ cwt.
Weight of Shot 41 lbs. 3 oz., charge 5 lbs.
Elevation by Tangent Sight.

Elevation . . .	0° 15′	0° 30′	1° 0′	1° 30′	2° 0′	2° 30′	3° 0′	3° 30′	4° 0′	4° 30′	5° 0′	5° 30′	6° 0′	6° 30′	7° 0′	8° 0′	9° 0′	10° 0′	20° 30′
Range	yds. 250	yds. 410	yds. 630	yds. 840	yds. 1040	yds. 1230	yds. 1410	yds. 1590	yds. 1770	yds. 1950	yds. 2130	yds. 2300	yds. 2480	yds. 2660	yds. 2850	yds. 3180	yds. 3520	yds. 3800	yds. 6184
Time of Flight .	″ 0·7	″ 1·1	″ 1·9	″ 2·5	″ 3·2	″ 3·8	″ 4·4	″ 4·9	″ 5·5	″ 6·0	″ 6·6	″ 7·1	″ 7·7	″ 8·3	″ 9·1	″ 10·2	″ 11·6	″ 12·8	

The above Ranges will answer for 40-Pr. Common, and Segment Shell.

RANGES FOR ARMSTRONG'S 6-PR. GUN, $3\frac{1}{2}$ cwt.

Weight of Shell 5 lbs. 13 oz.; charge $\frac{3}{4}$ lb.

Elevation by Tangent Sight.

Range	yds. 100	yds. 200	yds. 300	yds. 400	yds. 500	yds. 600	yds. 700	yds. 800	yds. 900	yds. 1000	yds. 1100	yds. 1200	yds. 1300	yds. 1400	yds. 1500	yds. 1600
Elevation . . .	° ' 0 6	° ' 0 15	° ' 0 25	° ' 0 37	° ' 0 53	° ' 1 10	° ' 1 30	° ' 1 47	° ' 2 7	° ' 2 30	° ' 2 47	° ' 3 10	° ' 3 32	° ' 3 55	° ' 4 17	° ' 4 40

Range	yds. 1700	yds. 1800	yds. 1900	yds. 2000	yds. 2100	yds. 2200	yds. 2300	yds. 2400	yds. 2500	yds. 2600	yds. 2700	yds. 2800	yds. 2900	yds. 3000	yds. 3100	yds. 3200
Elevation . . .	° ' 5 4	° ' 5 27	° ' 5 50	° ' 6 15	° ' 6 40	° ' 7 5	° ' 7 30	° ' 8 0	° ' 8 27	° ' 8 55	° ' 9 23	° ' 9 53	° ' 10 25	° ' 10 57	° ' 11 30	° ' 12 5

"NOTES ON NAVAL GUNS,

THEIR STORES AND FITTINGS."

By permission of the Lords Commissioners of the Admiralty.)

Guns, Dimensions, &c.

		Weight.		Length.				Total Weight of Gun Complete, with Ammunition and Stores.								
				Extreme over all.		Bore.		Revolving.			Side.			Add if Chase.		
		tons.	cwts.	ft.	in.	ft.	in.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.
Wrought Iron. M.L.R.	10 inch	18	0													
	9 „	12	0	13	0	10	5	† 818	0	9	†587	3	0	53	3	5
	8 „	9	0	12	0	9	10	† 625	0	17	†457	1	24	39	0	22
	7 „	6	10	11	0	9	3	408	3	1	309	3	13	25	2	0
	64-pr.	3	4	9	11·5	8	2	233	1	27	141	1	0	13	3	22
Wrought Iron. B.L.R.	7-inch	4	2	10	0	8	3·5	324	2	6	231	1	10	19	3	25
	40-pr.	1	15	10	1	8	10·375	159	3	14	93	1	2	9	0	26
	Heavy 20 „	0	15	5	6·125	4	6·125	..			48	0	7	..		
	Light 20 „	0	13					..			46	0	7	..		
	Boat 12 „	0	8	6	0	5	1·375	* 41	0	24	..			..		
	Field 12 „	0	8	6	0	5	1·375	46	1	8	..			..		
	Boat 9 „	0	6	5	2	4	4·5	34	2	24	..			..		
	6 „	0	3	5	0·125	4	5	..			..			..		
	Wedge 40 „	1	12	8	2	6	11·5	156	3	14	90	1	2	9	0	26
Wrought Iron. S.B. ..	150 „	12	0	13	0	10	5	642	1	9	493	3	3	33	3	0
	100 „	6	0	10	10·75	8	9·5	374	0	8	282	2	27	20	2	6
Cast Iron.	10-inch . . .	4	6	10	8·72	9	1·33	303	0	6	192	0	14	18	2	13
	8-inch . .	3	5	10	2·72	8	9·27	213	0	26	134	3	20	11	1	7
		3	0	10	0·86	8	7·35	208	0	26	129	3·20		11	1	7
		2	14	9	2·75	7	9·7	193	3	5	119	3	15	11	0	19
	68-pr.	4	15	11	4·55	9	5·9	286	3	22	218	1	6	14	2	20
	32-pr. .	2	18	10	7·45	9	0·65	167	1	16	109	3	5	6	3	26
		2	16	10	5·14	8	11·2	165	1	16	107	3	5	6	3	26
		2	10	10	0·42	8	7·08	150	3	10	99	0	19	6	3	9
		2	5	9	5·96	8	1·23	143	2	17	93	0	17	6	2	7
		2	2	8	11·91	7	7·25	134	3	17	87	1	2	6	1	3
		1	12	7	5·6	6	0·3	117	0	15	74	2	23	6	0	1
	O.P.	1	5	7	2·325	5	7·64	106	1	3	63	3	11	5	2	27
	N.P.			6	8	5	4·1									
Bronze.	6-pr. . . .	0	6	5	4·82	4	9·47	..			..			..		
	24-pr. Howtz. .	0	13	5	3·1	4	7·15	..			41	2	10	..		

† Add 16 cwt. 1 qr. 9lb., for running in and out gear.
* If with field carriage, 54 cwt. 2 qr. 16 lb.

Powder cases for
- 9, 8, and 7-inch M.L.R. . . . Corrugated.
- 150 and 100-pr. S.B. . . . . Rectangular
- 12, 9, and 6-pr. B.L.R. . . . . ½ M.L.
- the remainder . . . . Pentagon.

CHARGES AND PROJECTILES FOR RIFLED GUNS.

Guns.	Charges.			Shell, Empty, and Bursters.												Shot.						
				Common.		Double.		Segment.		Boxer's Shrapnel.				Chilled Palliser's.		Case.					Solid.	
																	Balls.					
																	Iron.					
	Battering.	Full.	Red.	Weight.	Burster.	Weight.	Burster.	Weight.	Burster.	Weight.	Balls.	Each Ball.	Burster.	Weight.	Burster.	Weight.	No.	Wt.	Musket.	Pistol.	Common.	Chilled.
	lbs.	lbs.	lbs.	lbs.	lbs. oz.	lbs.	lbs.	lbs. oz.	lbs. oz. dr.	lbs.	No.	oz.	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz.	No.	Wt. oz.	No.	No.	lbs. oz.	lbs. oz.
M.L.R. 10 in.																						
M.L.R. 9 "	43	30	15	232	18 8	..	..	..	..	250	437	3·	0 12	247 3	2 13	101 0	168	6	8	60	251 0	..
M.L.R. 8 "	30	20	12	167	13 0	..	..	..	..	182	315	3·	0 10	178 0	2 0	70 0	113	6	46	89	..	..
M.L.R. 7 "	22	14	10	107	8 8	146¾	12¾	..	..	111	200	3·	0 8	113 12	1 4	67 0	112	6	17	22	..	115 0
M.L.R. 64-pr.	..	8	6	59¼ 57¼	4 8 7 0	..	..	..	..	64¾	232	1·143	0 5	..	..	48 0	84	6	14	24	..	..
B.L.R. 7-in.	..	11	..	83¾	6 8	..	..	98 8	3 2 0	100	360	1·143	0 8	..	..	67 0	112	6	17	22	..	..
B.L.R. 40-pr.	..	5	..	38¾	2 4	..	..	39 0	0 13 0	..	..	..	..	..	..	30 0	71	4	15	41	41 4	..
B.L.R. 20 "	..	2½	..	20½	1 2	..	..	19 10	0 1 9½	..	..	..	..	..	..	15 0	†86	2	..	..	21 0	..
B.L.R. 12 "	..	1½	..	..	..	..	..	10 12	0 1 4	..	..	..	..	..	..	9 0	†69	1½	..	..	12 0	..
B.L.R. 9 "	..	1½	..	..	..	..	..	8 12	0 0 11	..	..	..	..	..	..						8 12	..
B.L.R. 6 "	..	0¾	..	..	..	..	..	5 12	0 0 7	..	..	..	..	..	..	4 12	†50	1	..	..	6 4	..

† Lead.

CHARGES AND PROJECTILES FOR SMOOTH-BORE GUNS.

GUN.	CHARGES.			SHELL.					SHOT.							
				Empty, Common.		Filled, Diaphragm.			Case.				Solid.			
										Balls.						
	Dist.	Full.	Red.	Weight.	Burster.	Weight.	Balls.	Burster.	Weight.	Weight.	Of each descrip-tion.	Total Number.	Cast.	Chilled.	Steel.	Wrought.
	lbs.	lbs.	lbs.	lbs. oz.	lbs. oz.	lbs. oz.	No.	oz.	lbs.	lbs. oz.	No.	No.	lbs.	lbs.	lbs.	lbs.
150-pr.	40	35	20	104 8	6 14	122 0	254* / 30	8	..	..	..	..	150	..	..	..
100 "	25	20	12	66 3	3 13	86 0	484	6	100	1 0	91	91	94·6	..	102	..
10-in.	..	12	8	77 11	6 5	..	..	..	82	1 0 / 0 13¼	34 / 50	84	..	..	..	..
8-in. 65 and 60 cwt.	10	8	5	47 1	2 9	60 13	341	5	..	0 8	90	90	..	..	..	..
8-in. 54 "	..	8	5						50½							
68-pr.	16	12	8	47 1	2 9	60 13	241	5	..	..	..	..	66·3½	69½	72	72
32-pr. 56 and 58 cwt.	10	8	6	21 10	1 5	23 15	154	3½	36½	0 8	66	66	31·4½	..	..	..
32-pr. 50 cwt.	..	8	5													
32-pr. 45 "	..	7	5													
32-pr. 42 "	..	6	4													
32-pr. 32 "	..	5	3													
32-pr. 25 "	..	4	2½													
How. 24-pr.	..	2½	..	16 1½	1 0	21 5	113	2½	16½	0 8	30	30	..	..	..	..
Brass 6 "	..	1½	½	..	..	5 13	31	⅜	8½	0 3½	41	41	6	..	..	..

* 2 oz. Sand Shot.

WEIGHT OF SNIDER'S MUSKET RIFLE, AND APPENDAGES, FOR SEAMEN.

	lbs.	oz.
Musket rifle, with rammer and sling	9	3
Sword bayonet and scabbard	3	2½
Belt, leather	0	7
Frog, sword or bayonet	0	3
Pouch, musket rifle	4	3
300 rounds of ball cartridge	31	0
Proportion of ½ case for ditto, 660 packed in case	8	4
180 rounds of blank cartridge	4	12
Proportion of ½ case for ditto, 2,400 packed in case	2	5
	63	7½
If blank cartridge is stowed in ¼ cases, add	0	10

Pistols, Revolver.	Deane's.		Colt's.	
	lbs.	oz.	lbs.	oz.
Pistol	2	7	2	9
Belt	0	7	0	7
Pouch	0	15	0	8
Holster	0	7	0	7
60 rounds of ball cartridge	2	2·5	1	9·6
Proportion of ½ case for ditto	0	9	0	7·6
60 rounds of loose ball and powder	2	2·5	1	9·6
	9	2	7	9·8

Swords, S.S.	lbs.	oz.	*Axes, Boarding.*	lbs.	oz.
Swords	2	6	Axes	2	9
Scabbards	0	12	Cases, leather, for ditto	0	6
Belt	0	7	Belts	0	7
Frog	0	3		3	6
	3	12			

Pikes, Boarding.	lbs.	oz.
Pikes	5	0

Carriages, Common and Rear Chock.

Weights, and Dimensions.

Description.				Weight. cwt.	qr.	lbs.	Length. Of Carriage. ft.	in.	Length. Of Gun and Carriage. ft.	in.	Length. From Centre of Trunnions to Muzzle. ft.	in.	Distance of Train Tackle Bolts from Ship's Side. ft.	in.
Common.	Rifled.		64-pr.* M.D.	8	3	0	5	0	9	8	5	8·5	14	0
Common.	Rifled.		64-pr.* U.D.	7	2	0								
Common.	Rifled.		40-pr. Screw	8	1	0	5	8	10	8½	6	1·12	14	4½
Common.	Rifled.		40-pr. Wedge	6	2	0	4	6	8	8	5	3·8	12	4
Common.	Smooth Bore.	8-inch.	65 cwt.	9	1	0	5	11	10	2	5	4·8	14	6
Common.	Smooth Bore.	8-inch.	60 "	9	1	0	5	10½	10	1½	5	3·6	14	5½
Common.	Smooth Bore.	8-inch.	54 "	8	1	0	5	5½	9	4½	4	9·6	13	8½
Common.	Smooth Bore.	32-prs.	58 "	9	0	0	6	0	10	6½	5	8·4	14	10½
Common.	Smooth Bore.	32-prs.	56 "	9	0	0	6	0	10	4½	5	5·1	14	8½
Common.	Smooth Bore.	32-prs.	50 "	8	0	0	5	7½	10	2½	5	6·15	14	6½
Common.	Smooth Bore.	32-prs.	45 "	8	0	0	5	7½	9	9½	5	2·47	14	1½
Common.	Smooth Bore.	32-prs.	42 "	7	2	0	5	2	9	2½	4	10·8	12	10½
Common.	Smooth Bore.	32-prs.	32 "	6	0	0	4	7	7	3½	3	8·58	10	11½
Rear Chock.			Rifled B. L. 20-pr.	4	2	0	4	5	6	7	3	3·5	10	3
Rear Chock.	Smooth Bore.		10-inch	13	3	0	6	5½	10	11½	5	7·2	14	3
Rear Chock.	Smooth Bore.		68-pr.	13	3	0	6	5½	10	8	6	0	14	6
Rear Chock.	Smooth Bore.		32-pr., 25 cwt.	4	3	0	5	2	7	3½	3	7·2	10	11½
Rear Chock.	Smooth Bore.		24-pr. Howitzer	4	1	0	4	5	6	2½	2	8·1	9	10½
6-pr. Brass			{top, under}	3	3	0	3	7	5	8½	2	9·33		

NOTE.—For the position of train tackle bolts, measure four times the length of the train tackle block from the rear of the carriage when the gun is in, i.e., with the muzzle at least one foot inside the inner port sill.

* *64-pr. carriages will require additional horns, with port sills less than 23 inches from the deck.*

Cases, Powder, Metal.

Dimensions, and Contents.

CORRUGATED.

Weight 49½ lbs.

Area of Front 219·655 ins.

22″·3 × 9″·85 × 22″·85.

Powder L. or F.G. 150 lbs.

Total weight filled, 202 lbs.

	Guns.	Charge. lbs.	No.
M.L. Rifled	-inch		
	10 ,,	50	2
		45	2
		35	3
	9 ,,	43	3
		30	4
		15	8
	8 ,,	30	3
		20	5
		12	10
	7 ,,	22	5
		14	8
		10	14
	64-pr.	8	18
		6	24
B.L.R.	7-inch	11	9
	40-pr.	5	20
	20 ,,	2½	30

	Guns.	Charge. lbs.	No.
S.B.	100-pr.	25	4
		20	6
		12	9
	10-inch	12	13
	8 ,,	10	14
		8	18
		5	17
	68-pr.	16	8
		12	12
		8	17
	32 ,,	10	14
		8	18
		7	21
		6	24
		5	30
		4	36
		2½	60
	24 ,, H.	2½	60

RECTANGULAR.

Weight 71 lbs.

Area of Front 242 ins.

22″·0 × 18″·5 × 11″.

Powder L. or F.G. 135 lbs.

Total weight filled, 208½ lbs.

	Guns.	Charge. lbs.	No.
M.L. Rifled.	-inch		
	10 ,,	50	1
		45	2
		35	3
	9 ,,	43	1
		30	3
		15	7
	8 ,,	30	3
		20	5
		12	9
	7 ,,	22	5
		14	7
		10	12
	64-pr.	8	16
		6	21
B.L.R.	7-inch	11	9
	40-pr.	5	17
	20 ,,	2½	30

	Guns.	Charge. lbs.	No.
S.B.	150-pr.	40	2
		35	3
		20	6
	100 ,,	25	4
		20	5
		12	8
	10-inch	12	10
	8 ,,	10	12
		8	16
		5	14
	68-pr.	16	7
		12	10
		8	16
	32 ,,	10	12
		8	16
		7	18
		6	21
		5	26
		4	32
		2½	61
	24-H.	2½	61

Cases, Powder, Metal.

Dimensions, and Contents.

Guns.		Charge. lbs.	No.	PENTAGON.	Guns.		Charge. lbs.	No.
M.L. Rifled.	9-inch	15	7	Weight 63 lbs.	S.B.	100-pr.	25	3
	8 ,,	30	2	Area of Front 205·4 ins.			20	4
		20	5	24-pr. Howitzer 2½ lbs. 44.			12	8
		12	9	15″·5 × 19″·5 × 11″·0 × 15″·5.		10-inch	12	9
	7 ,,	22	4	Powder L. or F.G. 120 lbs.		8 ,,	10	11
		14	7	Total weight filled, 185¼ lbs.			8	14
		10	11				5	12
	64-pr.	8	14			68-pr.	16	6
		6	19				12	9
B.L.R.	7-inch	11	7				8	14
	40-pr.	5	14				10	11
	20 ,,	2½	22			32 ,,	8	14
							7	16
							6	19
							5	22
							4	27
							2½	44

WHOLE.

Weight 47½ lbs.

Area of Front 282·24 ins.

17″·4 × 20″·8 × 16″·8.

Contents, as Pentagon or Hexagon Cases nearly.

Guns.		Charge. lbs.	No.	HALF.	Guns.		Charge. lbs.	No.
B.L.R.	20-pr. .	2½	12	Weight 31¼ lbs.	S.B.	24-pr. H.	2½	20
	12 ,, .	1½	25	14″·0 × 13″·4 × 10″·7.		12 ,,	1¼	40
	9 ,, .	1¼	32	Area of Front 187·6 ins.		6 ,, G.	0½	200
	6 ,, .	0¾	48					

Musket.

Cartridges, Rifled.

Ball	Patt. /53	1600
	Snider .	1500
Blank	do. .	2400

Powder, L. or F.G. 60 lbs.

Total weight filled 92¼ lbs

Cases, Metal, Half.

Will stow the same quantity as this case.

Cases, Powder, Metal Lined.

Dimensions, and Contents.

Pistol, Revolver.			Quarter.	Musket.		
Cartridges, Rifled.			Weight 18¾ lbs.	Cartridges, Rifled.		
Colt's . . .		*2250 / 3000	10″·8 × 13″·7 × 10″·2.	Patt. /53 . .		*700
Deane's . . .		*1920	Area of Front 110·2 ins.	Snider's Ball		660
				Snider's Blank		1110
* In waterproof bags.				* In waterproof bags.		
Guns.	Charge. lbs.	No.		Howitzers.	Charge. lbs.	No.
B.L.R. 20-pr. .	2½	4		24-pr. . .	2½	8
B.L.R. 12 ,, .	1½	9		12 ,, . .	1¼	16
B.L.R. 9 ,, .	1⅛	12				
B.L.R. 6 ,, .	0¾	18				

A TABLE showing the angles subtended by the Mainmasts of French ships of war, between the Water-line, and the Truck, with the corresponding distances.

(Taken from Sir H. Douglas's Naval Gunnery.)

The observer is supposed to be 20 feet above the level of the water.

	Line of Battle Ships.			Frigates.		Cor-vettes.	Brigs.	
	120 Guns.	90 Guns.	82 Guns.	60 Guns.	44 Guns.	24 Guns.	18 Guns.	
Yards.	Truck to the Water Line, 220 feet.	Truck to the Water Line, 202 feet.	Truck to the Water Line, 192 feet.	Truck to the Water Line, 188 feet.	Truck to the Water Line, 168 feet.	Truck to the Water Line, 120 feet.	Truck to the Water Line, 112 feet.	Yards.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
200	20 20	18 47	17 54	17 33	15 46	11 22	10 37	200
300	13 48	12 42	12 6	11 51	10 37	7 37	7 7	300
400	10 25	9 35	9 7	8 55	7 59	5 43	5 20	400
500	8 21	7 41	7 18	7 9	6 24	4 34	4 16	500
600	6 59	6 25	6 6	5 58	5 20	3 49	3 34	600
700	5 59	5 30	5 14	5 7	4 35	3 16	3 3	700
800	5 14	4 49	4 35	4 29	4 0	2 52	2 40	800
900	4 40	4 17	4 4	3 59	3 34	2 33	2 22	900
1000	4 10	3 51	3 40	3 35	3 12	2 17	2 8	1000
1100	3 49	3 30	3 20	3 16	2 55	2 5	1 57	1100
1200	3 30	3 13	3 3	2 59	2 40	1 54	1 47	1200
1300	3 14	2 58	2 49	2 46	2 28	1 46	1 39	1300
1400	3 0	2 45	2 37	2 34	2 17	1 38	1 31	1400
1500	2 48	2 34	2 26	2 23	2 8	1 32	1 25	1500
1600	2 37	2 24	2 17	2 14	2 0	1 26	1 20	1600
1700	2 28	2 16	2 9	2 7	1 53	1 21	1 15	1700
1800	2 20	2 8	2 2	2 0	1 47	1 16	1 11	1800
1900	2 13	2 2	1 56	1 53	1 41	1 12	1 7	1900
2000	2 6	1 56	1 50	1 48	1 36	1 9	1 4	2000
2200	1 55	1 45	1 40	1 38	1 27	1 2	0 58	2200
2400	1 45	1 36	1 31	1 30	1 20	0 57	0 53	2400
2600	1 37	1 29	1 24	1 23	1 14	0 53	0 49	2600
2800	1 30	1 23	1 19	1 17	1 9	0 49	0 46	2800
3000	1 24	1 17	1 13	1 12	1 4	0 46	0 43	3000
3200	1 19	1 12	1 8	1 7	1 0	0 43	0 40	3200
3400	1 14	1 8	1 5	1 3	0 57	0 40	0 38	3400
3600	1 10	1 4	1 1	1 0	0 53	0 38	0 35	3600
3800	1 6	1 1	0 58	0 57	0 51	0 36	0 34	3800
4000	1 3	0 53	0 55	0 54	0 48	0 34	0 32	4000

A TABLE showing the angles subtended by the Mainmasts of French ships of war, between the Water-line, and the Topmast crosstrees, with the corresponding distances.

(Taken from Sir H. Douglas's Naval Gunnery.)

The observer is supposed to be 20 feet above the level of the water.

Yards.	Line of Battle Ships.			Frigates.		Corvettes.	Brigs.	Yards.
	120 Guns.	90 Guns.	82 Guns.	60 Guns.	44 Guns.	24 Guns.	18 Guns.	
	Topmast Cross-trees to the Water Line, 158 feet.	Topmast Cross-trees to the Water Line, 151 feet.	Topmast Cross-trees to the Water Line, 138 feet.	Topmast Cross-trees to the Water Line, 139 feet.	Topmast Cross-trees to the Water Line, 121 feet.	Topmast Cross-trees to the Water Line, 85 feet.	Topmast Cross-trees to the Water Line, 77 feet.	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
200	14 52	14 13	13 2	13 7	11 28	8 5	7 20	200
300	9 59	9 33	8 45	8 48	7 41	5 24	4 54	300
400	7 31	7 11	6 34	6 37	5 46	4 3	3 40	400
500	6 1	5 45	5 16	5 18	4 37	3 14	2 56	500
600	5 1	4 48	4 23	4 25	3 51	2 42	2 27	600
700	4 18	4 7	3 46	3 47	3 18	2 19	2 6	700
800	3 46	3 36	3 18	3 19	2 53	2 2	1 50	800
900	3 21	3 12	2 56	2 57	2 34	1 48	1 38	900
1000	3 1	2 53	2 38	2 39	2 19	1 37	1 28	1000
1100	2 45	2 37	2 24	2 25	2 6	1 29	1 20	1100
1200	2 31	2 24	2 12	2 13	1 55	1 21	1 13	1200
1300	2 19	2 13	2 2	2 2	1 47	1 15	1 8	1300
1400	2 9	2 3	1 53	1 54	1 39	1 9	1 3	1400
1500	2 0	1 55	1 45	1 46	1 32	1 5	0 59	1500
1600	1 53	1 48	1 39	1 39	1 26	1 1	0 55	1600
1700	1 46	1 42	1 33	1 34	1 21	0 57	0 52	1700
1800	1 40	1 36	1 28	1 28	1 17	0 54	0 49	1800
1900	1 35	1 31	1 23	1 24	1 13	0 51	0 46	1900
2000	1 30	1 26	1 19	1 20	1 9	0 49	0 44	2000
2200	1 22	1 19	1 12	1 12	1 3	0 44	0 40	2200
2400	1 15	1 12	1 6	1 6	0 58	0 40	0 37	2400
2600	1 9	1 6	1 1	1 1	0 53	0 37	0 34	2600
2800	1 5	1 2	0 56	0 57	0 50	0 35	0 31	2800
3000	1 0	0 57	0 52	0 53	0 46	0 32	0 29	3000
3200	0 56	0 54	0 49	0 49	0 43	0 30	0 27	3200
3400	0 53	0 51	0 46	0 47	0 40	0 29	0 26	3400
3600	0 50	0 48	0 44	0 44	0 38	0 27	0 24	3600
3800	0 47	0 45	0 41	0 42	0 36	0 25	0 23	3800
4000	0 45	0 43	0 39	0 40	0 35	0 24	0 22	4000

PART X.

BATTERIES, AND FORTIFICATION.

BATTERIES.

A BATTERY, in respect to its profile, may be either elevated, half sunken, or sunken; and it is usually reveted with gabions, fascines, sand-bags, &c.

An elevated battery has its terreplein on the natural surface of the ground, and, to procure the mass of earth required for its parapet, a ditch is usually dug directly in front of the proposed parapet.

A half-sunken battery has its interior space, or terreplein, sunk some inches below the natural surface, and its parapet is composed of the earth thus obtained, and of that taken from a narrow ditch in front.

A sunken battery has the whole of the earth taken from the interior space to form the parapet; and it must therefore be lowered from 2 feet to 3 feet 6 inches, according to the height of the gun carriages to be used.

The half-sunken battery is constructed the quickest, as the diggers can work both in front, and rear, at the same time. In a sunken battery, the diggers are as much crowded as in an elevated one, but, since the mass of parapet to be raised is smaller, it may be completed in much less time.

Casemates, or vaulted batteries, are made bomb-proof, and the embrazures are cut through the revetment.

Barbet batteries have no embrazures, the guns being placed on traversing platforms to enable them to fire over the parapet.

A direct fire from a battery is when the line of fire is perpendicular to the parapet, and an *oblique fire* when it is oblique. The direct fire being preferable, the battery should be placed parallel to the object against which the fire is to be directed.

The line of fire is an imaginary line drawn through the centre of an embrazure, in the direction of the object against which a battery is constructed.

Embrazures are openings cut through parapets, flanks of bastions, &c., for guns to fire through.

The neck of the embrazure is the inward, or narrowest part of it.

The mouth of the embrazure is the outward, or widest part of it.

The sole of the embrazure is the bottom, or space, between the cheeks, or sides.

The sill is the inner edge of the sole.

The genouillere is that part of the parapet which is beneath the sill of the embrazure.

The merlon is the portion of the parapet contained between two embrazures.

The following dimensions are requisite to be proof.

Against musketry. Spherical bullet.	3 feet	when of	earth.
	6 inches	,,	stone.
	12 inches	,,	fir.
	5 inches	,,	oak.
	9 inches	,,	brick.

MAXIMUM PENETRATION OF ENFIELD RIFLE BULLET at ranges—from 20 to 200 yards.

Determined by Captain Whitmore, Royal Engineers.

Sandbags	12 inches.
Rammed sandy earth	16 inches.
Ordinary soil in parapet	3 to 4 feet.
Solid oak (across grain)	4 inches.
Ash, elm, beech	4 inches.
9 inch fascines	Not proof.
Full gabions, 2 inch diameter, earth rammed	Barely proof at diameter.
Do. do. not rammed	Not proof.
Rope mantlets, 13 lb. to square foot	3 bullets out of 9 stopped.
Sheet plates ¼ inch thick, 10 lb. per square foot (homogeneous)	Bulged, but not cracked with lead balls.
Do. do. ⅜ inch thick, 15 lb. per square foot	Unaffected by lead balls; slightly marked by steel tips.

*Dimensions to be proof against cannon.**

4 feet, when of wood, or brick.

6 feet	against 6-pounders,	when of earth.
9 ,,	9-pounders,	ditto.
14 ,,	12-pounders,	ditto.
18 ,,	18 & 24-pounders,	ditto.

NOTE.—A 6-pounder shot, with a charge of one pound, will penetrate *a mass of ice* to the depth of 4½ feet, at the distance of twenty-one yards.

GENERAL DIMENSIONS OF AN ELEVATED GUN BATTERY,

reveted with fascines.

	ft.	in.
Space from the centre of one embrazure to that of the next, without traverses	18	0
Ditto, with traverses	22	0
Slope of the interior revetment, per foot (one-fourth its height)	—	3
Fall of the superior slope, ditto (one-twelfth ditto)	—	1

* *Vide* "Penetration of the principal pieces of Ordnance," pages 83, 84.

	ft.	in.
Interior width of embrazures, measured on the sill . . .	2	0
Exterior ditto, measured on the sole, at 12 feet from the sill .	7	0
Slope of the cheeks of embrazures at the neck, per foot (one-sixth of their height)	—	2
Ditto, at the mouth, per foot (one-fourth their height) . .	—	3
Distance from the centre of an embrazure to the foot of the slope of an adjoining traverse	7	6
Distance from the centre of an embrazure to the foot of the slope of an adjoining epaulment	5	0
Height of the sill; gun, on a travelling carriage	3	6
„ „ standing carriage	2	4

POSITIONS OF BATTERIES.

All batteries for guns should be traced perpendicularly to their intended lines of fire.

Enfilading batteries are placed on the prolongations of the terrepleins to be enfiladed, and when ricochet fire with smooth-bored guns is used they should not be further off than 650 yards from the object; but with rifled guns enfilading batteries may be much further off, as, from recent experiments, ricochet fire, from these batteries, has been carried on with effect at 1,050 yards. In tracing the enfilading batteries, one gun should be placed on the prolongation of the crest of the work to be enfiladed, and the remaining guns on the *inside*, as regards the line enfiladed. Fire from enfilading batteries can be kept up by night as well as by day, as by fastening battens of wood to confine the trail, and the wheels of the gun-carriage to the proper line, the gun is sufficiently accurately laid to strike the terreplein (or other object) to be enfiladed.

Counter batteries are placed in front of the line of work to be silenced, but they need not be exactly opposite to it, for as they fire directly at the guns to be silenced, which are visible in the embrazures, any position of them will suffice from which the enemy's guns can be seen. Houses and other buildings in the line of fire of a counter battery are thus soon destroyed. Fire can be kept up on them only during daylight, as the object fired at (a gun in an embrazure) is too small to be able to be struck in night firing. This allows the garrison to repair damages and remount fresh guns every night.

DIRECTIONS FOR TRACING A BATTERY.

Batteries at sieges are generally traced in the dusk of the evening.

Detail of men, and tools required:

Tracers.—1 *non-commissioned officer, and* 2 *privates.*

Tools.—1 *ground-square.* 1 *measuring tape.*

1 *white tracing line.* 2 *ten-feet rods.* 1 *bundle of pickets.* 1 *mallet.*

Directions.—The tracing-pickets, and mallet, are carried in a sand-bag, and a few long pickets are necessary to mark the embrazures. A line should be stretched about 40 feet in the direction of the object

against which the battery is to be erected; this will show *the line of fire*. By means of a ground-square, a line may be laid down at right angles to the former, touching the first placed picket. This will be the interior base line. Another line must be placed parallel to this, at a distance equal to the sum of the breadth of the base of the parapet, breadth of the berm (if any), and breadth of the slope of the ditch (viz., about 27 feet), which line will represent the reverse slope of the ditch. A picket is then driven in on the interior base line, where it is intended to have one extremity of the battery, and as many long pickets (18 feet apart), measuring from this end, as there are guns, which will mark the centre of the embrazures. Then one more picket, 18 feet distant from the last, will show the other extremity. For the embrazures, drive in a picket at the distance of one foot on each side of the centre of the embrazures, for the width of the neck. Set off, and drive in pickets 3 feet 6 inches on each side of, and perpendicular to the line of fire, for the width of the mouth.

WORKING PARTY; TOOLS; AND MATERIALS REQUIRED

for each gun; mortar; traverse; or epaulment; in an Elevated fascine battery.

2 *sappers, with* 6 *assistants*, to revet the work.

12 *infantry*, to excavate the ditch, and form the parapet.

9 *pickaxes*, 15 *shovels, or spades*, 14 *fascines*, 18 *feet long*, 1 *bundle of* 50 *pickets to* 6 *fascines*, 3 *mauls*, 3 *rammers*, 1 *saw* to every two guns, 1 *hatchet* per gun, 1 *bill-hook*, 1 *field-service level*, 1 *six-feet rod*, 1 *bundle of matches* to every three guns, 1 *lantern*, do., 1 lb. *of candles*, do., 1 *bundle of gads* to each gun, 1 *tape of* 50 *feet in length* per battery.

A battery will seldom be completed in less than 24 hours, when executed by inexperienced workmen; but by those inured to hard labour, and with proper reliefs, in about 10 hours. In light soil, that can be easily dug without the aid of a pickaxe, a man can, in 8 hours, load from 19 to 20 cubic yards of earth on barrows. If a pickaxe be required, 2 men will do the same quantity of work. A man can wheel 20 cubic yards of earth per day to a distance of 30 yards on level ground, or 20 yards on a ramp. Twenty cubic yards of earth will fill 500 wheelbarrows. When near the surface, in soil requiring but little use of the pickaxe, an excavation of 6 cubic yards in a day of 8 hours would be a fair task for a soldier, who in general is little accustomed to working with the pickaxe, and shovel.

SHELTER FROM AN ENEMY'S FIRE.*

The following method of sheltering the workmen from the enemy's fire was used with great success during the construction of the batteries. It was towards the end of the siege that Lieutenant Néandre received orders to construct a battery 130 paces from the counterscarp, the

* *Vide* "United Service Magazine," No. CCCVIII.

covered way being strongly occupied by the enemy. Foreseeing the difficulties that would occur, Lieutenant Néandre provided 120 common platform planks, and, when the gabions were in their places, arranged the planks outside them, in such a manner as to present an inclined plane, (one end of the plank being supported on the gabion, and the other end resting on the ground towards the enemy): the gabions were then half filled with earth, and the pickets driven in. At this moment the enemy threw some fire balls, and fired a few shot, all of which went over. Soon after, the workmen were assailed with a well-sustained fire of musketry; but, on the balls striking the epaulment, they ricochéd, and passed over the workmen, so that not a single man was hit. The battery was finished in a few hours, when the planks were drawn in, and used for the platforms.

A portable framework might be rapidly made, and used instead of the gabions, to obtain immediate cover from musketry fire; and, for sapping, the framework, with the planks fixed thereon, might be readily moved on trucks, as a substitute for the present sap roller.

EPAULMENTS.

Batteries at sieges are generally secured on one flank at least, by a parapet called an epaulment, forming an obtuse angle with that of the battery. Their use is to secure the reverse of the terreplein, from any flanking fire, and they are not in general made so thick as the parapet, being seldom subject to a direct fire.

ELEVATED SAND-BAG BATTERIES.

The base of the interior slope of a battery reveted with sand-bags is rather broader than that of one reveted with fascines, being about one-third the height of the parapet. *Bushel sand-bags* are now the only kind in use, and *when filled are of the following dimensions:*

Length 20 *inches, breadth* 10 *inches, depth* 5 *inches.*

Number required per gun,—for the interior revetment	262
Ditto Ditto for the cheeks . . .	360
Total . . .	622

Sand-bags are laid *header*, and *stretcher*, as in masonry; the ends which are tied being always hid. As the sand-bags near the neck of the embrazure would be destroyed after a few hours' firing, and constantly require repairing, gabions, or casks should be substituted for them.

Howitzer batteries are similar to those for guns, except that the interior openings of the embrazures are 2 feet 6 inches, and the soles are raised, towards the front, about 10°, in order to cover the gunners as much as possible.

Mortar batteries are constructed with the same dimensions as gun batteries (the parapet being generally 8 feet high, and from 18 to 22 *feet thick), but,* as *they* have not embrazures, the ditch of elevated

batteries is made two feet deeper to obtain the requisite quantity of earth. A preference would in general be given to the sunken, or half-sunken profile for a mortar battery, on account of its requiring less time for its construction, and it being of no consequence whether the platforms are sunken, or otherwise. Mortars are placed at the distance of 15 feet from centre to centre of each other, where no traverses intervene; and the parapet has the same profile as a gun, or howitzer battery.

When fired at	45°	they are placed	12 feet from	the revetment.
Ditto	30°	ditto	13	ditto.
Ditto	20°	ditto	21	ditto.
Ditto	15°	ditto	30	ditto.
Ditto	10°	ditto	40	ditto.

HALF-SUNKEN BATTERIES.

The sill is about half its total height above the natural surface of the ground; the most convenient depth to which the terreplein may be sunk is 2 feet. The height of a sill for a travelling carriage will be 18 inches, and for a garrison carriage one foot above the natural level. The profile of the parapet is the same as in an elevated battery.

Number of sand-bags required for reveting one merlon.	180
Ditto ditto for cheeks of embrazures	360
Total	540

In forming the epaulment of a half-sunken battery, the earth is taken from a ditch in front, six feet wide, and about five feet deep.

SUNKEN GUN BATTERIES.

The soles of the embrazures are on a level with the natural ground, therefore the terreplein is sunk a sufficient depth for the solid, and the merlons are formed of the excavated earth. The height of the solid depends on the nature of gun carriage to be used. The first operation is to trace out the embrazures. The profile is the same as in the elevated battery. Should there be traverses, all the earth excavated from the interior will be required; if not, the overplus may be scattered in the rear.

RICOCHET BATTERIES.

Ricochet firing is the art of projecting shot, or shell, with a certain velocity, and in such a direction as to insure its striking the ground at any spot that may be required; afterwards making several grazes upon the earth, and destroying, or striking all that may oppose its progress. The piece of ordnance is loaded with a diminished charge of powder, and the elevation is from 3° to 10°, which causes the shot to bound or hop along the ground. The smaller the angle under which the shot is made to ricochet, the longer it will preserve its

force, and have effect, as it will sink in the same proportion so much less into the ground on which it bounds. In the ricochet of a fortress, or field-work, the elevation should seldom exceed 10° to throw the shot over the crest of the parapet; but in the field, the objects to be fired at being principally infantry, and cavalry, the guns need seldom be elevated above 3°; as, under greater angles, the shot would be apt to bound too high, thereby defeating its intended purpose.

Ricochet batteries should, if possible, be at a distance of 400 yards, or not exceeding 600 yards; as, from the uncertainty of the fire at a greater distance, at least two-thirds of the ammunition might be expended without producing any good effect.

The best elevation to enfilade a work being from 6° to 9° measured above the parapet, the charge should be regulated accordingly, which varies from one half, to one tenth the service charge.

Ricochet firing is very efficacious in dismounting the guns on the faces, or flanks of bastions, &c., the batteries for this purpose being erected on the prolongation of these works, and as nearly as possible perpendicular thereto, by which their whole length will be exposed to the effects of plunging, and destructive ricochet fire.

Vide Tables of Ricochet practice, pages 78, 84, 85.

REVETMENTS.

A *Revetment* is a support of any nature, constructed with the object of retaining earth at a slope steeper than it would stand by itself. The names of the materials in general use for reveting the slopes of field works are sods, gabions, fascines, and sand-bags; or casks, planks, hurdles, &c., may be used.

Sods are usually cut 1 foot 4 inches long, 8 inches broad, and 4 inches thick.

FASCINES.

Fascines are strong fagots, usually made 18 feet in length and 9 inches in diameter; if shorter ones are required they are sawn into 6 or 9 feet lengths. Before fascines can be made, fascine trestles, or horses, have to be set up in the following manner:—Five pairs of stakes, each 6½ feet long and about 3 inches in diameter, are driven obliquely into the ground, crossing one another like the letter X, at 2½ feet above the ground, where they are secured by means of rope-yarn, &c. Each pair of stakes forms a trestle. The extreme trestles are first set up 16 feet apart, the three others are then set up in a straight line, and so as to divide this interval equally.

To make a fascine, brushwood is laid along the trestles, so as to project about 17 or 18 inches beyond their extremities, the thick and thin wood being equally distributed in the length of the fascine, and the thick wood kept as much as possible on the outside. When the proper quantity has been placed, the brushwood is fastened, and secured by withes, or gads. Twelve gads are used to each fascine, 18 inches apart, *the extreme ones* being 9 inches from the ends of the fascine. To fasten

the gads a choker is used to compress the brushwood to the proper diameter. The choker consists of a couple of wooden levers 4 feet long, joined with a chain 4 feet long, fixed at 18 inches from the ends.

After the compressing is finished, and the gads fastened, the fascine is completed by trimming the projecting twigs, and by sawing the ends square at the distance of 18 feet apart. The average weight of an 18 feet fascine is about 140 lbs. The following tools are required for each squad of 5 men, viz.: 5 pairs of stakes, and lashings, for the trestles, 1 choker, 1 maul, 1 handsaw, 3 billhooks, 2 gabion knives, 1 6-feet rod, 1 grindstone, or several whetstones for several squads.

The *gads* are made of rods 5 feet long, first twisted until the fibres separate, the smaller end is then turned round, so as to form a loop, or noose. To make a fascine 6 feet long, the workmen set up three fascine horses on the same level, and in a right line.

(*A fascine horse* is formed with two pickets, each 5 feet long, driven about 1 foot obliquely into the ground, so as to cross each other at right angles 2 feet above the surface of the earth; and they are fastened together at their point of meeting, with cord, three or four-thread spun yarn, or gads.) The brushwood, which should not exceed from 1½ to 2 inches in diameter at the butt end, stripped of all its leaves and smaller branches, and 5 or 6 feet long, is then laid on the fascine horses, the thick ends being placed alternately at each end. The large stuff must be used to form the exterior, and the smaller twigs the interior of the fascine. Before binding the fascine, it must be compressed with a *fascine choker*, which consists of a cord, or chain, equal in length to one and a half times the circumference of the fascine, fastened at one end to a lever 5 feet long and 2½ inches in diameter, with a loop at the other end, into which, after passing the chain round the fascine near the part to be bound, a lever, similar to the one already described, is inserted, and the brushwood is squeezed tightly together until the gad is tied. The fascine must be compressed in a similar manner before each gad is fastened. *The weight of the fascine* is about 33 lb. *Three men can make a 6-feet fascine in twenty minutes.* Two of the workmen place the brushwood, while the third prepares the gads. If large brushwood can be procured, the fascines should be 18 feet long, the strength of the revetment being materially increased by diminishing the number of joints. *When the fascines are* 18 *feet long*, they are made 9 inches in diameter, and are bound with 13 gads, if the brushwood is good, but with 17 if it is bad, the fascine horses being 1 yard apart. *This fascine weighs* about 2 cwt. *Four men can make an* 18*-feet fascine in two hours*, or, if the wood be cut and brought to them, they can make four fascines in that time. *They require* 3 *bill-hooks*, 1 *saw*, 1 *fascine choaker* (*each lever about* 6 *feet long*), *and* 6 *fascine horses*. Three men prepare the brushwood, and lay it on the horses, while the fourth makes the gads.

The revetment is formed in proportion as the parapet is raised, the first fascine being half buried in the banquette, with three pickets *driven vertically* through it, each picket being from 3 to 4 feet long, *and from 1¼ to 1½* inch in diameter at the thickest end. The second

row of fascines is then laid a little in front of the first, so as to form the required slope, and three pickets are driven through each fascine; the extreme pickets through the fascine previously laid in the direction of the slope, the other perpendicular to the slope.

The joints of the different rows of fascines should be so broken that no two adjoining joints may be in the same line, and the ends of the fascines at the angles should alternately be flush with, and be inserted in the parapet; care being taken to lay the fascines so that the ties of the gads may be concealed in the parapets. Six rows of large fascines are sufficient to form the revetment of a parapet, the upper row being covered with a layer of sods, the grass upwards. When fascines of seven inches in diameter are used, eight rows are required.

GABIONS.

Gabions are strong cylindrical baskets, having open ends; their dimensions are 2 feet 9 inches high in the web, and 2 feet in diameter. The gabion is made in the following manner: A circle of 11 inches radius is traced on the ground; pickets, from $\frac{5}{8}$ to $\frac{7}{8}$ inch thick, and 3 feet 6 inches long, are next driven into it, at equal distances from each other; the pickets are 12 in number, if ordinary brushwood be used; 8 or 10 if the brushwood be coarse, and a greater number if it be slender and weak. The waling, or basket-work, is then commenced, with rods usually stripped of leaves and twigs. Three rods are used at a time. They are first placed with the butts inwards, and the tips outward, being separated from each other by intervals of one picket. The first rod, which is to the left hand, is brought to the front by being passed outside two pickets, inside the next picket, and above the other two rods. The second rod, which is then to the left, is, in its turn, brought to the front, by being passed outside two pickets, and inside one. The third rod is then treated in the same way, passing outside two pickets, inside one, and above the two preceding rods. Hence each rod comes in turn to the front; and a web is thus formed round the pickets. In making the gabion the web must be continually pressed down with the foot, or hand, or beaten with a mallet, and the greatest care taken to preserve the proper diameter, by constantly applying the gauge or measuring-rod. The top and bottom of the gabion are finished with twisted withes worked alternately in and out of the pickets. When the web is 2 feet 9 inches high, it must be bound from top to bottom with withes, previously well twisted, in four distinct places, so applied as to secure the ends rather than the middle of the external rods. The upper part of the gabion being thus secured by withes, or sewing gads, is pulled out of the ground, turned upside down, and treated in the same manner, so that the two sets of withes may meet and cross each other about the centre of the gabion. Before the gabion is pulled out of the ground, the tops of all the pickets must be cut off about an inch and a half above the web. The tools required for each squad of 3 men are, 1 bill-hook, 2 gabion knives, 1 4-feet *measuring rod*, 3 gauges cut out of the brushwood, 1 chopping-block,

1 mallet, and 1 grindstone (for several squads), or whetstone in lieu thereof. The average weight of a brushwood gabion is 35 or 40 lbs.; but if thick wood be used, they will frequently weigh as much as 60 lbs. These gabions are required in great numbers during siege operations, where they are indispensable for reveting batteries, &c., but their disadvantages are numerous; they are heavy and clumsy to carry, require much labour to make, and are combustible and perishable. These defects are so well known, and so important, that of late years two kinds of iron gabions have been introduced into the service.

The sheet-iron gabion (invented by Captain Tyler, R.E.) is formed of a sheet of galvanised iron, 3 feet wide, and 6 feet 2 inches in length; at each end are three holes, having metal eyes. The sheet, being bent round into a cylinder until the eyes at the opposite ends come together, is fastened, in that form, with three wire hooks, which are attached to the eyes of one side. The gabion, thus formed, stands 3 feet high, and 2 in diameter; it weighs 26 pounds, and is carried, like the common gabion, by means of a picket passed through it, for which purpose two holes are provided in the iron sheet.

The iron band gabion (invented by Quartermaster T. Jones, R.E.), is composed of 10 bands of sheet iron, each 6 feet 5 inches in length, and 3½ inches in breadth; each band has two buttons at one end, fitting into two holes, or slots, at the other. Twelve wooden pickets are used with the bands to form the gabion.

To put the gabion together two men are required. One of the bands, with the ends joined together, is placed edgewise on the ground, thus forming a circle 2 feet in diameter; the pickets are then driven into the ground round the band, at equal distances from one another, and alternately on the outside and inside of the band, and touching it; the other bands are then placed in succession over the pickets, taking care that each band is outside those pickets that were inside the adjoining band, and *vice versâ*, and are then pressed down on to the band last placed; no fastening is necessary to keep the bands on the pickets. The gabion weighs about 29 lbs., of which the pickets weigh 5 lbs.

Suspension-bridges to carry field artillery, &c., have been made with these sheet-iron bands buttoned together, and the inventor proposes to put them to many other uses, such as roofing huts, forming camp bedsteads, &c.

SAP ROLLERS.

Exterior cylinder, length, 6 feet, diameter, 4 feet.
Interior „ „ 6 „ „ 2½ „

Pickets { Exterior cylinder, 20 / Interior „ 14 } 6 feet long, by 1 to 1½ inch diameter.

Rods, 1 inch thick.

Pickets for stuffing, 1½ inch diameter: average space between cylinders, 8 inches.

Time for making large cylinder, 9 hours; small cylinder, 6 hours; *and 2 hours for stuffing.*

SOD, OR TURF.

The sods should be cut from good meadow land, previously mown, and watered; but the sods should not be laid or built when wet, because they would shrink in dry weather, and all the joints would open. The sod-work is laid with the grass downwards, either alternately headers, and stretchers, or two stretchers to one header; care being taken that the joints of no two rows fall immediately over one another, which is termed breaking joint. If the layers of sods are laid perpendicular to the slope, they will answer better than if laid horizontally. Each sod should have two or three pegs driven through it, to secure it to the work beneath. When the revetment is completed, the whole should be cut off smooth to the proper slope.

PLATFORMS.

To facilitate the working of a gun, it must be placed on a platform of stone, or timber, and plank: but, as a temporary measure, when required to fire only in one direction, timbers to take the wheels will suffice. The usual inclination given to platforms, from the rear to the front, is half an inch per foot. Platforms on barbettes should be perfectly level, and their dimensions must depend on the extent of the lateral range which may be required.

In laying a gun platform, the first thing to be done is to fix the *hurter*, which may be a piece of timber 7 or 8 feet long, and 7 inches square, or a strong fascine 9 feet in length may be advantageously used. The hurter is intended to take the wheels, or trucks of the carriage when the gun is run out, and to prevent their damaging the interior slope of the parapet. The position of the hurter necessarily depends therefore on the steepness of the interior slope. The hurter should be placed perpendicular to the axis, or central line of the embrazure. Three, four, or five sleepers, of from 6 to 8 inches square, are then laid, their upper surface on a level with the bottom of the hurter, and they are covered with two inch planks, nailed down when three sleepers are used; but if there be four or five sleepers, the planks may be confined by two *ribbands* (which are pieces of wood of the same length, but weaker scantling than the sleepers), and the platform racked down with *rack lashings* at the proper intervals.

A *rack lashing* consists of a piece of 2-inch rope about 9 feet long, which is fastened to a stick 15 inches long, 2 inches wide at the head, with a hole in it to receive the lashing, and tapering to a blunt point: it is passed round the timber, and sleeper beneath, then twice round itself. The end of the stick is then put into the loose gromet so formed, and twisted round until the whole is firmly secured, when the stick is turned flat on the upper piece of scantling.

The gun and mortar platforms for sieges are now made rectangular: the dimensions of the former are 15 feet long by 10 feet 6 inches broad; those of a mortar platform are 7 feet 6 inches long by 6 feet 6 inches broad. Mortar platforms are laid exactly horizontal, the

front part being placed 5 feet within the foot of the interior slope of the parapet.

Alderson's platform.

The platform invented by Colonel Alderson, R.E., is 15 feet long, by 9 feet wide; and is composed of 46 similar pieces of timber (baulks), each measuring 9 feet × 5 inches × $3\frac{1}{2}$ inches. Of these, ten are used as sleepers, and the remainder as planking. The weight of the platform (when 15 feet long and 9 feet wide) for guns is 15 cwt. 2 qrs. 14 lb. By addition of the small beams, this platform may easily be extended from 15 to 18 feet.

Dimensions, and Weight of Platforms, for Guns, &c.

Nature of Platform, and articles required.	Number.	Length.		Breadth.		Thickness.		Weight.		
		ft.	in.	ft.	in.	ft.	in.	cwt.	qr.	lb.
GUN, AND HOWITZER.										
Sleepers	5	15			5		5	4	2	1
Planks	20	10	6		9		2	7	3	22
Ribbands	2	15			4		4	1	0	18
Rack-sticks, and lashings										10
Total weight . .								13	2	23
MORTAR.										
Covered with oak planks.										
Sleepers	7	7	6		6		6	3	3	7
Planks	10	6	6		9		3	5	1	22
Ribbands	2	7	6		4		4		2	10
Rack-sticks	10	1	3							15
Total weight . .								9	3	26
Made entirely of fir.										
Sleepers	7	7	6		6		6	3	3	7
Planks	8	6	6		11¼		4	4	2	18
Ribbands	2	7	6		4		4		2	10
Rack-sticks	8									12
Total weight . .								9	0	19
MADRAS.										
Wood-work										
Side-pieces	2	12	6	1	0		4	3	0	18
Trail-piece	1	12		1	4		4	1	1	3
Fore transom	1	7			6		6		2	19
Hind transoms	2	6	6		9		3		2	20
Sleepers	3	9			6		6	2	0	16
Wedges	2								2	7
Iron-work.										
Long bolts, ⅞-in. diameter	2		11½							6
Short bolts, ditto . .	6		7½							11
Total weight . .								8	2	16

GUN, AND HOWITZER PLATFORM.

For carrying this platform, two men are required for each sleeper; one man for each plank, and ribband. The non-commissioned officer carries the rack sticks.

A platform may be laid down in an hour by expert men, and may be dismantled in three minutes.

MORTAR PLATFORM.

Detailed as above. One non-commisioned officer, and seventeen men carry the platform. *Time required for laying down, and dismantling*, similar to the above.

MADRAS PLATFORM.

In an elevated battery, the platform may be laid down by expert men in half an hour, *and may be dismantled* in three minutes.

BREACH.

The best place for making a breach, in ravelins, bastions, &c., is about thirty yards from their salient angles. The batteries should commence by marking out by their fire the extent of the breach intended to be made, first by striking out a horizontal line as near the bottom of the revetment as possible, and afterwards two others perpendicular to, and at the extremities of this line. Should the breach be required to be extensive, it will be necessary to form intermediate lines. Then, by continuing to deepen these two or more cuts, and occasionally firing salvoes at the part to be brought down, the wall will give way in a mass. The guns must, however, at first fire low, and gradually advance upwards until the breach is effected; and when the wall has given way, the firing should be continued until the slope of the breach is made practicable.

FOUGASSES.

Fougasses are small MINES, of which the shafts or pits are from 3 to 10 feet deep. The charge of powder for any depth in ordinary soil is found by cubing the depth in feet, and by dividing the result by 10 for the required charge in pounds. In most cases it is preferable to have many small fougasses rather than a few large ones. The powder is placed in a cubical box, well tarred to protect it from damp, and is placed in a recess, called the *Chamber*, on one side of the shaft at the bottom. It is fired from a secure spot by means of a *powder-hose*, or *Saucisson*, enclosed in a wooden trough, which is carried up one angle of the shaft, and thence along a trench parallel to the surface. The trough should be 5 or 6 feet below the surface, if there is any danger of shells falling upon it; if not, a depth of 2 feet will suffice. *After the* charge is placed, and the saucisson laid, the shaft is filled up *with earth*, well rammed. The position of the Fougass should be *concealed from* the enemy's view. A second method of firing Fougasses,

is to place a loaded musket with the muzzle in the charge or the priming, and to fasten a wire to the trigger; the wire can be led in the required direction, in the same manner as the hose, in a wooden trough, and being pulled at the proper moment, the explosion will take place. The most perfect method of firing mines is, however, by electricity, either by the voltaic, or the magneto-electric battery.

TO BURST OPEN GATES OF FORTRESSES, ETC.

A leathern bag, containing about 50 lb. of powder, should be hooked upon the gate, as near the centre as possible (or be laid on the ground, close to the bottom of the gate, and tamped with sods, &c.), and be fired by means of a piece of portfire, or match, passed through a hole in the bottom of the bag.

SCALING LADDERS.

Scaling ladders are made in portions, 12 feet, and 7½ feet long; which are joined together by placing the end of one portion into staples at the end of another, and securing them together with a lashing of rope. Four men are sufficient to carry an 18 feet scaling ladder.

FORTIFICATION.

Offensive fortification is the art of conducting a siege.

Defensive fortification comprehends military architecture, and is the art of securing, or protecting a place by works, to resist a siege.

Natural fortification consists of obstacles, such as marshes, mountain passes, &c., which should be taken advantage of to impede the approaches of an enemy.

Artificial fortification comprises those works which are constructed to defend a place.

Permanent fortification is the art of putting towns, &c., into such a state as at all times to be prepared to resist the attack of an enemy.

Field fortification is the method of fortifying a camp, or position, buildings, &c., and it includes the construction of redoubts, entrenchments, &c. Works of this nature are considered as temporary.

Irregular fortification is the art of fortifying a place of an irregular figure, situated where the country does not admit of giving to the several works their due proportion according to rule.

A Command is the vertical elevation of one work above another, or above the country.

A Command in front is when an eminence is directly facing the work which it commands.

A Command in the rear, or reverse, is when any eminence is directly behind the work which it commands.

A Command by enfilade is when an eminence is situated in the prolongation of any line of a work, and a considerable part of it may be seen from thence; this line will be subject to enfilade, and such a command is the most dangerous.

The Rampart (A T R) is an elevation of earth, obtained from the excavation of the ditch; and is that part of the fortification which is situated between the ditch, and the town; consisting of an interior slope, terreplein, banquette, parapet, and exterior slope or escarp.—(*Vide Plate.*)

The Interior slope (A) is the inclination of earth nearest to the town.

The Terreplein (*T*) is the upper part of the rampart, which remains after having constructed the parapet.

The Parapet (R) is a mass of earth elevated on the terreplein of the rampart, on the side towards the country; being from 18 to 22 feet thick, and from 6 to 8 feet high. The top is formed with a slight declivity towards the country, which is called the *superior slope*, so constructed that the fire of musketry over it may be directed on the boundary of the counterscarp of the ditch, when the ground is level; but, when commanded by the enemy, the crest must be raised in proportion.

The Banquette is an elevation of earth, or step, on which the soldiers stand to fire over the parapet.

The Revetment is the masonry which retains the earth of the rampart on its exterior side. It is about 5 feet thick at the top, and its slope is one-fifth, or one-sixth its height.

The Berm is a space, or path, sometimes left between the exterior slope of the rampart, and the ditch. It serves as a communication round the works, and prevents the earth falling into the ditch.

The Tablette is a flat coping-stone, on the exterior of the top of the escarp of whole revetment.

The Cordon is a semi-circular projection of stone, whose diameter is about one foot, placed at the top of the slope of the revetment of the escarp.

The Escarp (a) is the exterior slope, or wall of the rampart.

The Counterscarp (b) is the wall, or slope of the ditch, opposite to the escarp.

The faces of a work (p q) are those parts which form a salient angle, projecting towards the country.

The Flank (q G) is the part of a work so disposed as to defend another; joining the face of a bastion to the curtain, &c.

The Bastion (M L) is a work composed of two faces, and two flanks. Bastions are joined by curtains, and are constructed salient, and with flanks, in order that the whole escarp may be seen, and that a reciprocal defence may be obtained.

Bastions are of various kinds—viz., full (M), empty (L), also flat, detached, demi, and tower bastions.

A Full bastion (M) is when the terreplein occupies all the interior space of the bastion. From the description of this bastion, that of all the others may be ascertained, according to their distinctive appel*lations.*

The Curtain (G R H) is that part of the rampart which lies between *two bastions*, and joins the flanks thereof.

A Front of fortification consists of two half bastions, and a curtain.

The Ditch (B) is an excavation from 12 to 24 feet deep, and from 90 to 150 feet broad, surrounding the rampart. The side of the ditch nearest the place forms the escarp (a); and the opposite part, the counterscarp (b) is made circular opposite to the salient angles of the works.

The Covered way (V) is a space of about 30 feet broad, extending round the counterscarp of the ditch, being covered by a parapet from 7 to 9 feet high, with a banquette.

The Glacis (X) is the superior part of the parapet of the covered way, forming a gentle slope towards the country, and terminating at from 120 to 180 feet; it covers the revetment of the body of the place.

The Places of arms of the covered way are spaces contrived in the salient, and re-entering angles of it; those (c) in the re-entering angles flank the branches of it, and contain troops for sallies, and its defence; and those (P) in the salient angles serve for assembling the Troops destined for the defence of the covered way.

The Sallyports are openings cut in the glacis, at the faces of the re-entering places of arms, and at the branches of the covered way. They are used in making sallies from the covered way.

The Traverses (n) in the covered way, are parapets which cross the breadth of it at the salient, and re-entering places of arms, &c. They cover the troops who are drawn up behind the parapet of the covered way, from the enfilade fire of the enemy. They have passages cut in the parapet of the covered way, close to the traverses, in order to form a communication from one part of the covered way to another: these passages are about 6 feet wide, and are provided with gates.

A Citadel is a fortress joined to the works of a place, and is fortified both towards the town and country. It should always be situated on the most commanding ground, serving to keep the inhabitants in awe, and, should the town be taken, it becomes a retreat for the garrison.

The Esplanade is a space of even ground, clear of buildings, situated between the town and citadel.

The Body of the place (or *Enceinte*) consists of the work next to, and surrounding the town, in the form of a polygon, whether regular, or irregular.

Outworks are those works which are constructed beyond the body of the place, such as tenailles, ravelins, &c.

The Tenaille (D) consists of two faces, and a small curtain. It is constructed between the flanks of the bastions in front of the curtain, and has a terreplein, parapet, and banquette.

The Ravelin (P) is constructed opposite the curtain (in front of the tenaille), is composed of two faces, which form a salient angle *towards the country*, and of two demi-gorges formed by the counter-*scarp.*

A Horn-work is composed of two half-bastions, and a curtain, with two long sides directed upon the faces of the bastions, or ravelins, so as to be defended from them.

A Crown-work is composed of a bastion between two curtains, which are terminated by half bastions. It is joined to the body of the place by two long sides.

Lunettes, and *Tenaillons* are works (consisting of two faces) constructed on each side of ravelins.

A Flèche, or *Arrow*, is constructed along the foot of the glacis before the re-entering, and salient places of arms. It consists of a parapet, whose faces form a salient angle, and are about 120 feet long, and it has a communication with the covered way, cut through the glacis.

The Caponnière (Y) is a work intended to cover a passage across the ditch. That from the tenaille to the gorge of the ravelin is a road about 30 feet wide, covered on each side by a parapet 7½ feet high, its superior slope terminating in a glacis about 60 feet wide.

A Cunette is a small ditch made in the middle of a dry ditch, to drain off the water from the place, &c.

A Batardeau (e) is a solid piece of masonry, 7 or 8 feet thick, crossing the whole breadth of the ditch opposite the flanked angles of the bastions. It retains the water in those parts of the ditch which require to be inundated.

A Ramp (t) is a road cut in the interior slope of the rampart, forming a communication from the town, &c., to the terreplein.

A Cavalier is a work constructed upon the terreplein of a full bastion, being from 8 to 12 feet above the rampart, with a parapet 6 feet high. Its use is to command some rising ground within cannon-shot, and to serve as a traverse for preventing the neighbouring curtains from being enfiladed.

Parallels, or *Places of arms*, thrown up at sieges, are trenches formed to connect together the several approaches to a besieged place.

Zig-zags, or *Boyeaux of communication*, are trenches made for the approaches from the parallels to the besieged place. They are generally 3 feet deep, and have a parapet, and banquette.

A Redan consists of two faces forming a salient angle (which should not be less than 60°) with parapet, &c.*

A Lunette has two faces similar to the redan, and also two flanks.*

A Redoubt is a square, polygonal, or circular field fort.*

A Star fort consists of a succession of salient, and re-entering angles, formed on the sides of a polygon. These forts are usually constructed on a triangle (when they have six salient points), or a square (having eight salient points).*

Têtes de pont, or *Bridge heads*, consist of redans, &c., which are constructed upon the banks of rivers, to protect the passage across them.*

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* *Vide* FIELD FORTIFICATION, pages 302, 303, 304.

Lines are formed for the entrenchment of armies, and are composed of a succession of redans, &c., (joined by curtains,) which should not be more than 120 yards distant from each other, to afford mutual protection, and defence.*

An Epaulment is an elevation of earth thrown up to cover troops from a flanking fire.

Loop-holes are oblong holes, from 15 to 18 inches long, 6 inches wide within, and 2 or 3 without. They are cut through timber, or masonry, for the service of small arms.

Palisades are stakes of strong wood, 8 or 9 feet long, and 6 inches thick, fixed about 3 feet in the ground, and 3 or 4 inches asunder.

Fraises are a kind of palisades, placed horizontally, or obliquely in the exterior slope of ramparts.

A Stockade is formed of rough timber, the logs of which are 8 or more inches in thickness, are sunk about 3 feet in the ground, and are at least 7 feet above the earth. The logs should be well secured together near their tops by a beam. Unless breached by artillery fire they require to be surmounted either by means of ladders, or by forming a breach in them by exploding a bag of gunpowder against them.

Chevaux de frise consist of a piece of timber from 9 to 12 feet long, and about 6 inches in diameter, into which staves are inserted cross-ways, about 9 inches asunder, about 2 inches thick, 6 feet long, and pointed at the end if not shod with iron. Their use is to stop up a breach, defend a passage, or form an intrenchment against cavalry. Chevaux de frise are sometimes made entirely of iron.

Abattis consist of trees with their branches shortened, and sharpened at the ends: they are used instead of chevaux de frise on an emergency.

Hurdles are about 3 feet high, and 2 broad, and are used in sieges to stop up breaches, &c.

Trous de loup are holes dug in the ground in the form of an inverted cone, about 6 feet deep, and 4½ in diameter at the top, having a picket fixed in the centre of the bottom, 6 feet long, and 4 or 6 inches square, the point being on a level with the upper surface of the ground. These pits are used to prevent the approach of bodies of cavalry.

PERMANENT FORTIFICATION.

Remarks, and general rules.

The ground plan, and relief of bastioned fortifications are mutually dependent on each other; and, as a variety of causes occur to influence both according to the various sites occupied, it is impossible to give them any fixed arrangement, and dimensions, applicable under all circumstances. However, under the supposition that the site to be fortified is a horizontal plane, a great number, and variety of systems

* *Vide* FIELD FORTIFICATION, pages 302, 303, 304.

have been proposed at different times; almost every author, who has treated of fortification, having invented one, at least, of his own. Notwithstanding this diversity of opinion, as to the best system, all agree that the following general principles should not be lost sight of in the construction of fortifications.

1. Salient angles should be as large as possible, and never less than 60°. The larger they are, the smaller will be the space in front undefended by direct fire. If less than 60°, the salients of earth are too acute to stand firmly for any length of time; and the angles of masonry are easily damaged: besides which, the space within the parapets becomes too restricted to admit of a gun being worked near the angle.

2. Angles of defence should be right angles, or slightly obtuse. If less than right angles, the fire from the flanking works might injure the defenders of the works they flank; as troops generally, and more particularly at night, fire in a direction perpendicular to the parapet; and if too obtuse the fire might be directed wide of its object. Besides, embrazures should be cut as direct as possible; as the more they are oblique, the more they weaken the parapet.

3. The length of the lines of defence shall be such, that the works defended may be within the effective range of the projectiles used.

4. The works should be so disposed that the assailants may not be able to obtain cover in any part of the exterior, within range of the projectiles of the defenders.

5. The escarps of the body of the place should be of such height, or construction, as to be secure against escalade.

6. The masonry should be sufficiently covered from the view of the enemy, to prevent his making a practicable breach from a distance.

7. The interior of every work should be completely covered from the view of an enemy outside it; so that he may not be able to fire directly into any part of it. Interior works should therefore have a command over those in front of them, at least equal to the height which a besieger can give to the parapets of his lodgments, and which is seldom less than 3 feet.

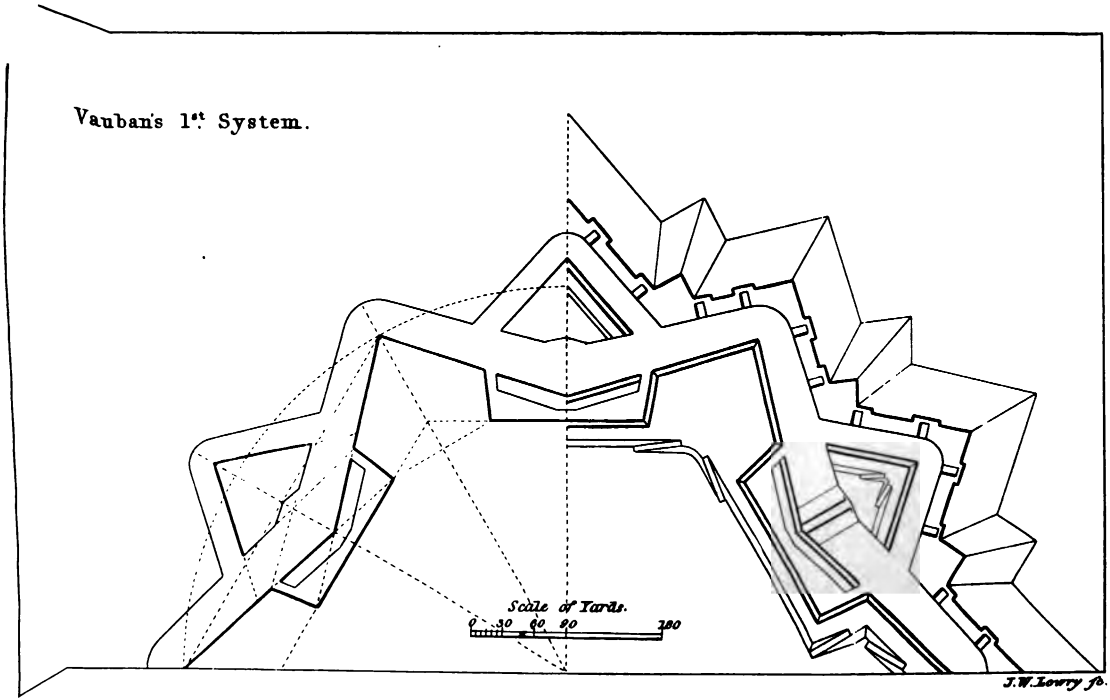
8. Every opportunity should be seized of so directing the faces of works that an enemy may not have it in his power to enfilade them by ricochet fire.

9. In the general construction of fortifications the salients should be few, and sufficiently prominent to force the besieger to take them before he can attack the re-entering parts. The object of this is to reduce the number of points of attack, as the fewer they are, the less advantage an assailant derives from his numerical superiority.

10. Permanent fortifications must be considered very incomplete without a sufficiency of casemated cover for the sick, and wounded, and for the portion of the garrison off duty. The magazines of ammunition and provisions, should also be secure from the effects of shells; and the supply of water ample, and certain.

11. Small enclosed works, in which the defenders must be crowded, without cover from vertical fire, should never be employed in perma-

Vauban's 1st. System.



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nent fortification. The strength they impart can never make up for the loss the garrison must suffer by them.

12. Outworks, and detached works should have easy communications with the main work, to admit of their garrisons receiving reinforcements, or supplies, when necessary; and to enable them to retreat, when the works are no longer tenable.

13. Every enclosed defensive work of importance should, if possible, be provided with a keep, or citadel, or interior entrenchment, to which the garrison may retire when the main enclosure (or enceinte) is forced.

14. Outworks, and detached works near the body of the place, should be so constructed that the enemy, when he has taken them, may not be able to use them as defensive works.

15. Outworks, and detached works, should always be of sufficient strength to force the enemy to make *regular* attacks on them. Advanced works of a weak construction are likely to do more harm than good; for the troops of the garrison seeing them taken with comparative facility, would naturally lose confidence in the strength of their remaining defences, while that of the aasailants would be increased by early success.

16. All fortifications should be provided with means of egress, and ingress, to enable the garrison to assume the offensive, whenever opportunities offer; and to admit reinforcements into the fortress.

17. There are very few fortified places that agree with any published system, though some resemble one or other of the systems, or consist of combinations, or modifications of them. The systems which have been wholly, or partly carried into execution are, of course, the most interesting, and form valuable subjects of study. A knowledge of their advantages, and defects, and the best methods of attacking, and defending them, will enable the military student properly to appreciate works which have been, or are to be constructed; and the operations by which fortresses have been, or may be captured.

VAUBAN'S FIRST SYSTEM.

To describe three Fronts of fortification, on a hexagon.

Vide Plate.

With a radius of 360 yards, the length of the exterior side of the fortification (taken from a scale of equal parts), describe a semicircle, which divide into three equal parts, and draw lines to the points of division; thus forming *three exterior sides*. Bisect each of these by perpendiculars drawn to the centre of the polygon, on which set off $\frac{1}{6}$th of the exterior side (if a hexagon),* through which points draw *the Lines of defence;* on these set off $\frac{2}{7}$ths of the exterior side, from the angles of the circumference, for the length of the faces of the bastions ;

* *For a square,* the length of the perpendicular is 1-8th the exterior side; *for a pentagon* 1-7th; for the hexagon, and other polygons, 1-6th.

with radius of the distance between the two faces describe arcs joining the lines of defence, and draw the chord of these arcs for *the flanks of the bastions;* a line joining the interior extremities of the flanks will give the length of *the curtains.*

Or to describe one Front of fortification.

For the exterior side draw a line 360 yards in length, at the ends of which, lines are to be directed to the centre of the polygon, at the angle required; (*vide* PRACTICAL GEOMETRY—*To find the angles at the centre, and circumference of a regular polygon,*) then bisect the exterior side, and draw the perpendicular, &c., &c., as described, above, for the construction on a hexagon.

Main ditch.

From the salient angles of the bastions, with 38 yards as a radius, describe arcs, to which draw tangents, directed to the angles of the shoulders of the bastions.

The Tenaille.

Draw lines parallel to the lines of defence, at the distance of 16 yards, for the faces of the work; its flanks, and curtain are constructed parallel to the flanks of the bastions, and curtain, at the distance of 11 yards.

The Ravelin.

From the re-entering angle of the counterscarp, make the capital of the ravelin 80 yards in length, and from its summit draw lines to points, on the faces of the bastions, 11 yards from the angle of the shoulder; the junction of these lines, and the counterscarp of the main ditch will determine the length of the faces of the ravelin. The gorge is formed by drawing lines 24 yards from the re-entering angle of the counterscarp to the intersection of the perpendicular, and the exterior side. From the salient angle of the ravelin, with a radius of 24 yards, describe an arc, to which draw tangents parallel to the faces, for the breadth of the ditch.

From the outline of the works draw the following parallels inwards:—

Rampart.

1. At the distance of 6 yards, for the thickness of the parapet.
2. From which 12 yards, for the breadth of the terreplein.
3. From which 6 yards, for the breadth of the interior slope.

Tenaille.

Draw lines parallel to the faces, at the distance of 6 yards, for the parapet.

Ravelin.

To the faces of the work draw the following parallels:—

1. At the distance of 6 yards, for the parapet.

2. From which 8 yards, for the terreplein.
3. From which 5 yards, for the interior slope.

Covered way.

Draw lines parallel to the counterscarp, at the distance of 11 yards, for the breadth of the covered way.

Salient places of arms.

These are formed by the salients of the branches of the covered way.

Re-entering places of arms.

Set off 40 yards on each side of the re-entering angle of the counterscarp for their demi-gorges, from which points draw their faces at an angle of 80 degrees inwards.

Glacis.

For its breadth, draw parallels to the branches of the covered way, and the re-entering places of arms, at the distance of 50 yards.

Traverses.

Those at the re-entering places of arms are erected perpendicular to the covered way; those at the salient places of arms are formed on the prolongation of the faces of the bastions, and ravelins, across the covered way; all the traverses are 6 yards thick at the top. The passages, cut out of the glacis, to enable the troops to pass round the traverses, are 4 yards wide.

Ramps.

Flanked angle of the empty bastion.—From the angle of the interior slope set off 16 yards on each side, from which points draw lines 42 yards in length diagonally along the interior slope for the length of the ramps; to which draw parallels, 4 yards distant for their breadth; erect perpendiculars from the points (16 yards from the angle) until they intersect each other, from which point as a centre, with radius of the distance between the ramps, describe an arc joining the head of the ramps of the two faces; concentric to which, with a radius 6 yards less than the former, describe another arc, to which draw tangents from the termination of the ramps, representing their slopes.

Gorge of the full bastion.—From the angle of the interior slope, set off 16 yards on each side, from which points draw lines 42 yards in length diagonally along the interior slope; draw parallels to these at the distance of 5 yards, for the breadth of the ramps; erect perpendiculars at their head, from the intersection of which as a centre, with radius of the distance between them, describe an arc, parallel to which, with radius 6 yards less, describe another arc, to which draw tangents, completing the interior slope of the ramps.

Flank of the empty bastion.—Set off 42 yards, from the angle of the flank of the interior slope, diagonally along the slope, for the length of the ramp, to which draw a parallel line 5 yards distant, for

the breadth, prolonging it to the top of the interior slope, and setting off 6 yards for the interior slope at the head of the ramp; to which point, from the end of the ramp, draw a line; and also from the same point draw another line parallel to the prolongation of the side of the ramp, and joining the interior slope of the face of the bastion.

Ravelin.—From the angle of the interior slope, set off 12 yards on each side; from these points draw lines 30 yards in length, diagonally along the interior slope, for the length of the ramps; to which draw parallels 4 yards distant for their breadth; erect perpendiculars at the commencement of the ramps, and from their intersection, as a centre, with radius of the distance from the ramps, describe an arc joining the two ramps: also from the junction of the perpendiculars draw lines to the termination of the ramps, for their slopes.

Caponniere.

Make the passage of this work 10 yards wide, including the banquette on each side: the superior slope of each parapet terminates at 20 yards' distance.

Bridges, and communications.

These are from 4 to 5 yards wide.

Stairs, or *Pas de souris.*

These steps of masonry are made at the gorges of the several works, and at the salient, and re-entering angles of the counterscarp. Those at the salients are generally 24 feet long, and at the re-entering angles 30 feet; they are 5 feet wide, and their steps 1 foot distant from each other.

Sally-ports.

These passages, cut through the glacis, are about 4 yards wide, and 6 yards long.

PROFILE, OR SECTION OF VAUBAN'S FIRST SYSTEM.

Construction.

The interior slope of the rampart has a base of 18 feet, and a perpendicular height of 17 feet 6 inches.

The terreplein has a breadth of 25½ feet, its height being 18 feet sloping to 17 feet 6 inches, the height of the interior slope.

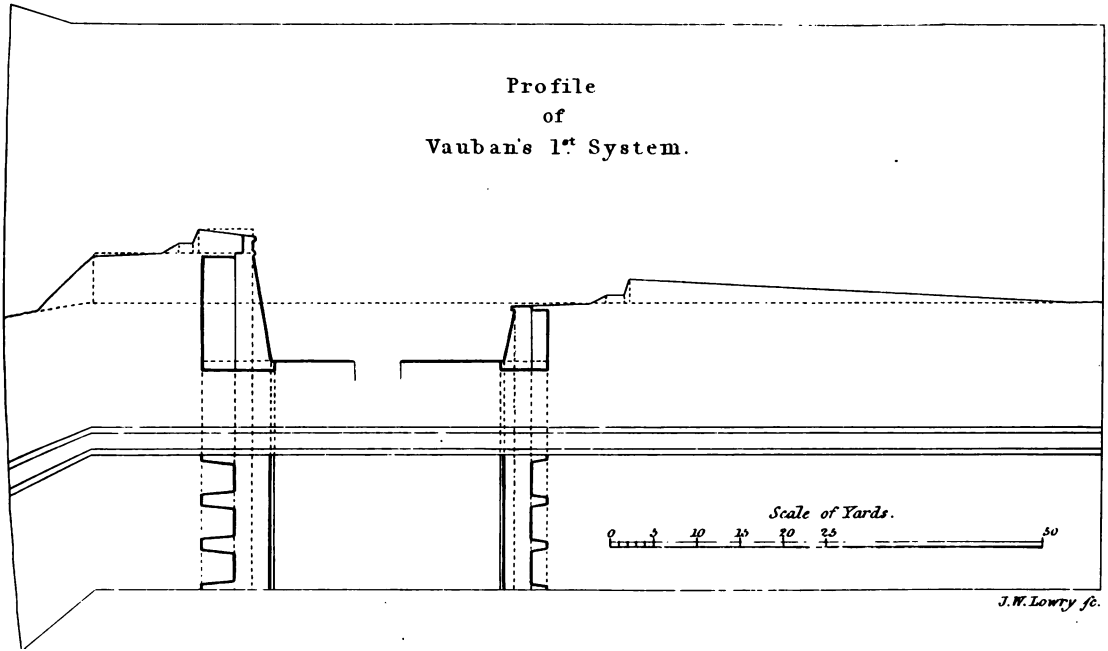
The banquette is 3 feet in height, the tread 4 feet wide, and the slope 5 feet wide.

The parapet is 4 feet 6 inches higher than the banquette, its interior slope is 18 inches, its thickness 18 feet, and its superior slope has a declivity of 3 feet; the revetment is 3 feet thick.

The escarp has a perpendicular height of 36 feet, measuring from the cordon to the bottom of the ditch.

The tablette, or coping-stone, at the top of the revetment, has a projection of 6 inches square.

The cordon is semicircular, its radius being 6 inches.


Profile
of
Vauban's 1st System.
Scale of Yards.
0
5
10
15
20
25
50
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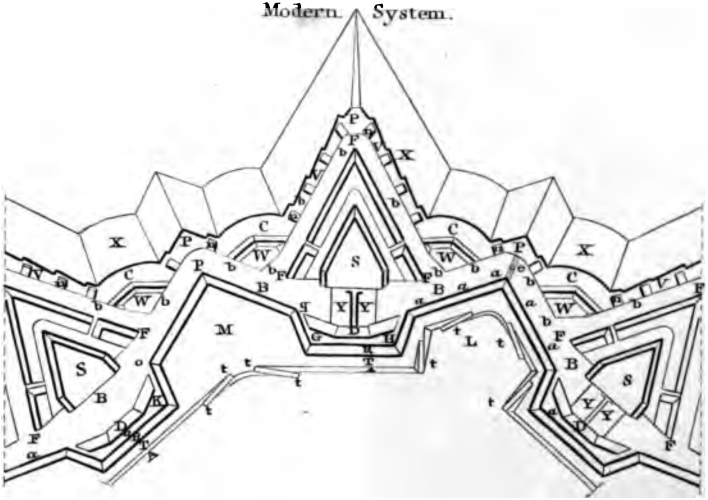
FORTIFICATION.

Modern System.



The slope of the escarp is 6 feet, the thickess of its revetment at the top 5 feet, and at the bottom 11 feet.

The counterfort joins the escarp: it is 1 foot lower than the top of it, 9 feet wide, and it extends to the bottom of the foundation, which is 3 feet below the bottom of the escarp; the retreat, or lessening, has a width of 1 foot.

The ditch is 38 yards wide, from the salient angle of the bastion.

The counterscarp is 17 feet 6 inches in perpendicular height, its slope being 3 feet, and its thickness at top 3 feet, the bottom, therefore, having a thickness of 6 feet; the foundation is 3 feet; and the retreat 1 foot.

The terreplein of the covered way is 20½ feet wide, and its slope is 6 inches. The banquette is 3 feet high, its tread 5 feet, and its slope 6 feet. The parapet is 4 feet 6 inches above the banquette, and its interior slope is 18 inches. The glacis, which forms the superior slope of the parapet of the covered way, is 50 yards in breadth.

The counterfort of the counterscarp is 5 feet in thickness, being 1 foot lower than the top of the counterscarp, and extending as low as the foundation of it.

The counterforts of the escarp, and counterscarp are 15 feet distant from centre to centre of each other, those of the escarp being at the end adjoining it 5 feet 6 inches, and at the termination 3 feet 8 inches thick; those of the counterscarp being in thickness at the larger part 3 feet 6 inches, and at the smaller 2 feet 4 inches.

Vide Plate.

MODERN SYSTEM.

A	Interior slope.	D	Tenaille.
T	Terreplein of rampart.	Y	Caponniere.
R	Parapet of rampart.	e	Batardeau.
A T R	Rampart.	F F F	Ravelin.
a a a a	Escarp, or exterior slope, of rampart.	S	Redoubt in ravelin.
		b	Counterscarp.
M	Full bastion.	n	Traverses in covered way.
L	Empty bastion.		
p q	Face of bastion.	c	Re-entering places of arms.
q G	Flank of bastion.		
K o p q G	Outline of bastion.	W	Redoubt in ditto.
G H	Curtain.	P	Salient places of arms.
t	Ramps.	V	Covered way.
B	Ditch.	X	Glacis.

FIELD FORTIFICATION.

REMARKS, AND GENERAL RULES.

1. The size of a work depends in general upon the number of men who are to defend it. If labour is the sole object of attention, *the advantage* must necessarily be the greater in proportion as the

size of the work is less; but if the accommodation of the troops is only to be considered, the advantage depends greatly upon occupying much ground.

2. The form of the work should be such as to contain the greatest surface with the least perimeter. By an adherence to this maxim, we obtain the greatest accommodation for the troops with the least labour. The form of a field work seldom depends upon choice, but generally upon the spot where it is to be raised, the purposes for which it is to be constructed, and the nature of the ground in the vicinity.

3. The interior of the work ought to be so covered by the parapet, that the men within, except when on the banquette, may not be seen from any part without, at the distance of cannon-shot.

4. The circumjacent ground (to as great a distance as possible) ought to be cleared, that the enemy may not conceal, or shelter himself against the fire from behind the parapet. The nearer to the work that the enemy can find cover, the more advantageously he can form his dispositions; and, as his attacks may consequently be made with greater vigour, and be more readily supported, the success will be more probable.

5. The flanking parts ought to be sufficiently capacious to contain all the men required for the defence of the flanked portions of the work.

6. The flanking parts ought to have nearly a direct view of those flanked; that is, the defence should be nearly at right angles, the most advantageous angle being 100 degrees.

7. The parts flanked ought to be within musket fire of their flanking parts.

8 The fire ought to be equally distributed, that every part of the work may be equally defended.

9. The work ought to be equally strong in all its parts, that it may everywhere equally resist the assaults of the enemy; and the parapet should be thick enough to withstand the shot fired against it.

10. The dimensions of the parapet should not only be sufficient to secure, and cover the troops within the work, but ought also to be of such a form as to afford a full view of the enemy in his approach; and at the same time discover, as little as possible, the men employed for its defence.

The required thickness of parapets is dependent on the nature of ordnance employed, or expected to be employed by the enemy in the attack of the work, *vide* pages 83, 84, 304, as a guidance in the construction of the Profile of Parapets for Permanent, and Field works.

A Plate of "Profiles of parapets" has not been introduced into "The Artillerist's Manual" (as intended), the destructive power of projectiles being constantly on the increase; to meet which the defensive resistance of parapets must similarly advance, to render parapets (*by means of* iron, stone, brickwork, as well as wood), if possible, ***proof against*** every nature of ordnance employed in attacking defensive ***works.***

Capacity of Field works.

The perimeter of a Field work, and the number of men to defend it, should bear a just proportion to each other, according to the nature, and object of the work: *Linear measurement* (on the crest of the parapet) 1 yard being allowed for each man, or for each file of men; and 5 or 6 yards for each gun: *Superficial measurement* (area within the banquette) 2 square yards for each man, and 36 square yards for each gun. Various authors, English and French, have published rules for determining the size of Field works, and there is a great discrepancy in their conclusions: the following rule (adopted at the Royal Military College) for computing the area, and perimeter of a square Redoubt will, however, meet the general requirements of these works.

Multiply the given number of men by 2, and the number of guns by 36, for the number of square yards which the work ought to contain within the foot of its banquette: the square root of the product will be the length, in yards, of the side of the square forming that area: add to this result, the breadth of the two interior slopes of the parapets, and of two banquettes, with their slopes (altogether about 7 yards), and the length of the side of the square, formed by the crest of the parapet, will thus be determined.

Rules.

1. *To find the quantity of earth* required for the Parapet, and Banquette of a field work, &c.

Divide the parapet, and banquette into trapezoids, and triangles; compute the contents of each separately (*by the rules in* MENSURATION OF PLANES), and the sum of them will be the superficial content of a section of the parapet, and banquette. Multiply this by the length of the perimeter, or periphery of the redoubt, battery, &c., for the solid content of the parapet, and banquette.

In square redoubts, or works having salient angles, if the areas of the sections of the parapet, and ditch, are made nearly equal, there will be too much earth. Bearing this in mind, previous to commencing the excavation of the ditch, an allowance must be made for the angles, to prevent any excess of earth for the parapet, and banquette.

2. *To find, rapidly,* the quantity of earth required for a Parapet, and Banquette.

Multiply the height of the crest of the parapet, into the sum of the bases of the superior, and exterior slopes; which will give the superficial content, very nearly.

3. *To compute the superficial content of the Ditch.*

Multiply the depth into the breadth at bottom, to which product add the areas of the escarp, and counterscarp, for the content required.

4. *To find the breadth of the Ditch,* of the usual form.

Divide the area of the section of the parapet by the intended depth *of the ditch,* and the quotient will be the mean breadth of the ditch;

to this add half the sum of the bases of the slopes of the escarp, and counterscarp, for the breadth at top, and deduct the same for the breadth at bottom.

5. *To find the breadth of the Ditch*, having a triangular section.

Divide the area of the section of the parapet by half the given depth of the ditch, and the quotient will be the required breadth at the top.

Construction of Field works.—Vide Plate.

Fig. 1. *The redan.*

Draw a base line, 60 yards from the centre of which erect a perpendicular, 40 yards; join the terminations of the base, and perpendicular, which will form the crest of the parapet of the work.

Fig. 2. *The lunette.*

Construct a redan (*vide No.* 1), base 80 yards, perpendicular 50 yards: make the faces of the lunette 45 yards in length, and draw the flanks to points on the base line, 30 yards, from the perpendicular.

Fig. 3. *The square redoubt.*

Construct a square, each side 40 yards, (*vide* PRACTICAL GEOMETRY). To form additional faces when required, bisect the side of the square, draw perpendiculars inwards equal to ⅛th of the side, and join the termination of the perpendiculars, and the sides of the square, thus forming a double number of faces.

Fig. 4. *The pentagonal redoubt.*

Describe a circle, radius 30 yards, and construct a pentagon in the circle (*vide* PRACTICAL GEOMETRY), thus forming the crest of the parapet of the redoubt.

Fig. 5. *The hexagonal redoubt.*

Describe a circle, radius 30 yards, and construct a hexagon within it (*vide* PRACTICAL GEOMETRY); the sides of which form the crest of the parapet of the work.

Fig. 6. *The circular redoubt.*

Describe a circle, radius 30 yards, which will form the crest of the parapet of the redoubt.

Fig. 7. *The star fort, with six points.*

Construct an equilateral triangle, and divide each side, 75 yards, into three equal parts: form also an equilateral triangle on the central portion of each side, 25 yards, and the crest of the parapet of the fort will be traced.

Fig. 8. *The star fort, with eight points.*

Construct a square: divide each side, 60 yards, into three equal *parts*, and on the central portion, 20 yards, describe an equilateral *triangle*: the periphery of the fort will thus be obtained.

FIELD FORTIFICATION.

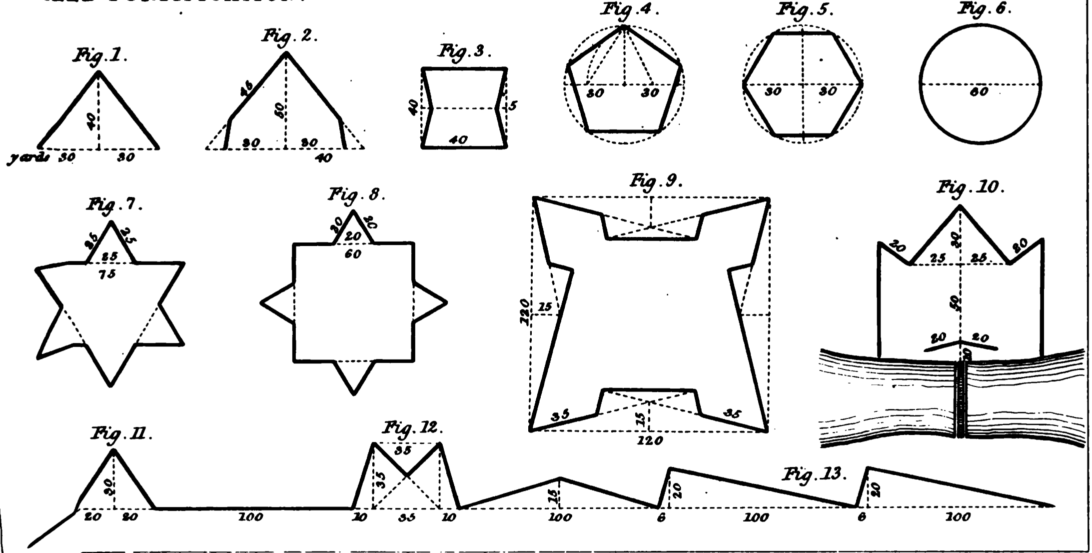


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Fig. 9. *The field fort, with bastions, and half bastions.*

Construct a square; from the centre of each side, 120 yards, drop a perpendicular equal to one-eighth of the side, through the extremity of which, from the angles of the square, draw the lines of defence; make the faces of the bastions, and half bastions, two-sevenths of the exterior side, and draw the flanks perpendicular to their respective lines of defence.

Fig. 10. *The bridge head, or tête du pont.*

Construct a redan, base 50 yards, perpendicular 30 yards, at an appropriate distance from the bridge, 50 yards; draw flanks, 20 yards, perpendicular to the faces, and from their termination draw lines to the river parallel to the capital of the work. To strengthen the interior defence of the tête du pont, construct a flèche, faces 20 yards each, and 10 yards in front of the bridge, which is 4 yards wide.

In the construction of bridge heads, the foregoing Figures may be employed when expedient; the simplest form, the redan, being for light bridges; and the more perfect defence, the bastioned front, or fronts, for bridges of material consequence.

Figs. 11, 12, 13. *Lines.—Vide Plate.*

Fig. 11. Construct a redan, base 40 yards, perpendicular 30 yards; which join by a curtain, 100 yards, to a queue d'aronde.

Fig. 12. Side of square, 35 yards, and lines drawn from summit to points on the curtains 10 yards. To increase the defence of the next curtain, 100 yards, bisect it by a perpendicular, 15 yards, and draw the two faces. Lengthen the lines by cremaillères.

Fig. 13. Base 100 yards; crochet, base 5 yards; perpendicular 20 yards.

Lines, continuous, are formed by a modification of redans, lunettes, curtains, &c., dependent on the nature of the ground, and the means of defence.

Lines, with intervals, are formed by detached redans, lunettes, &c., within range of each other; the rear works flanking those in front.

Bridges, and passages into field works are from 6 feet to 12 feet wide, according to the requirements.*

Traverses are placed about 9 feet from the slope of the banquette, their length being so regulated as to exclude from the view of the enemy the interior of the field work, through the bridge, &c.*

The nature, and form of the field work, or lines, required for the defence of a post, &c., &c., having been determined, the perimeter may be laid down, in conformity to the construction detailed in the foregoing figures: after which the requisite dimensions of the parapet, ditch, &c., (dependent, of course, on the nature of the enemy's ordnance) must be taken into consideration, and the quantity of earthwork com-

puted by the *Rules*, pages 300, 301, or by those in PRACTICAL GEOMETRY. The following Table will, however, in many cases be found useful; and, by a judicious adaptation of it, much time may be saved in the computation, and construction of field works.

TABLE,

showing the dimensions, in feet; and the superficial content of earth of banquettes, parapets, and ditches, of field works.

	BANQUETTE.				PARAPET.								BERM.	DITCH.				
					Interior slope.		Superior slope.		Exterior slope.									
Number.	Base of slope.	Tread.	Height.	Superficial content.	Height.	Base.	Height.	Base.	Height.	Base.	Superficial content.		Berm.	Breadth at top.	Escarp slope.	Counterscarp slope.	Depth.	Superficial content.
1	6	5	3	24	7½	1½	7½	15	5½	5½	120½		3	26	3	3	6	138
2	6	4	3	21	7½	1½	7½	15	5	5	114½		3	20	4	4	8	128
3	6	5	3	24	7½	1½	7½	12	5½	5½	101		3	23	3	3	6	120
4	6	4	3	21	7½	1½	7½	12	5	5	98⅜		3	17	4	4	8	104
5	6	4	3	21	7½	1½	7½	9	5½	5½	81½		3	19	3	3	6	96
6	6	4	3	21	7½	1½	7½	9	5½	5½	81½		3	16	4	4	8	96
7	5	4	3	19½	7½	1½	7½	6	6	6	66⅜		2	18	3	3	6	90
8	5	4	3	19½	6	1	6	6	4½	4½	44⅝		2	15	10	5	8	60
9					8	1½	8	12	5½	5½	102½		3	19	3	3	6	96
10					7½	1	7½	9	5½	5½	78		2	16	4	4	6	72
11					6	1	6	6	4½	4½	44⅝		2	12	4	3	6	51
12					6	1	6	3	5¼	5¼	33 5/16		2	9	6	3	8	36
13	4	4	3	18	7½	1	7½	4	5½	5½	44½		2	15	10	5	8	60

SIMPLE METHODS OF TRACING FIELD WORKS, ON THE GROUND.

1. *Square redoubt.*

Place pickets in a line (in length conformable to the side of the intended work), at each end of which erect perpendiculars equal in length to the side first marked out, and join the termination of these lines; which will complete the perimeter of the redoubt.

Note.—A perpendicular is raised on a given line, with a chain or cord, by forming a right-angled triangle from the numbers 3, 4, and 5, or any multiples thereof, and extending the cord, &c., so that the base may correspond with the base line of the pickets, and the perpendicular be in the direction of the side required.—*Vide* PRACTICAL GEOMETRY.

2. *Pentagonal redoubt.*

With a chain, tape, or cord, construct, and lay down with pickets *five similar*, and contiguous triangles, having their bases, which form

the sides of the pentagon, in the proportion of 47 to the other two equal sides, the length of each of these being 40.

3. *Hexagonal redoubt.*

From a central point with a chain, or line, construct, and lay down with pickets, six equilateral, and contiguous triangles, the bases of which will form the required hexagon.

4. *Octagonal redoubt.*

Construct a square (*vide* No. 1), from the centre of each side of which erect perpendiculars outwards, in length proportional to the side as 13 to 60 (nearly 1 to 5); join the extremities, or termination of the perpendiculars, to the angles of the square, which will determine the sides of the octagon.

Note 1.—The directions for the construction of the pentagonal, and hexagonal redoubts are on a small scale; but the redoubts may be increased by the equal extension of the interior sides of the triangles, until the bases are sufficiently long for the periphery of the work required.

Note 2.—By means of the pocket sextant, prismatic compass, or reconnoitring protractor, the pentagonal, hexagonal, and octagonal redoubt may be thus traced on the ground. From a central point place pickets at the requisite distance from each other, and in the direction of lines drawn from the angle of the centre of the intended work. (*Vide* PRACTICAL GEOMETRY. *To find the angles at the centre, and circumference of a polygon.*) Extend these radii equally until the relative distances between them are of the length required to form the sides of the proposed equilateral redoubt.

5. *Front of fortification, for a Field fort.*

Place pickets in a straight line, of the length required for the front of the proposed field work; from the centre of which drop a perpendicular inwards, making it for a square, pentagon, or hexagon, respectively one-eighth, one-seventh, or one-sixth of the exterior side. Direct the lines of defence from the termination of the exterior side to the end of the perpendicular, making the faces of the bastions two-sevenths of the exterior side, and constructing the flanks perpendicular to, and joining the lines of defence. Other fronts are traced by laying down the exterior sides, at the angle of the circumference of the intended polygon (*vide* PRACTICAL GEOMETRY), by means of the prismatic compass, &c., and then proceeding as directed for the former front.

PART XI.

BRIDGES, AND PONTOONS.

BRIDGES.

1. *To find the number of planks required to form a float, to support a given weight.*

1st. Find the content of one plank (*vide* PRACTICAL GEOMETRY, *Part* 13), and multiply it by the specific gravity of the wood; the product will be the *weight of the timber.*

2nd. Multiply the same solid content by the specific gravity of water; the product will be the *weight of an equal bulk of water.*

Then take the difference of these two products, or weights, and it will be the weight one piece of timber will support without sinking. *Hence by Proportion*, the number required to support the given weight may be found.

Note.—A fir tree, 1 foot square and 25 feet long, will float about 703 pounds.

2. *To find the number of casks required to form a raft to support a given weight.*

1st. Find the solid content of one cask, in cubic inches (*vide* PRACTICAL GEOMETRY), and multiply it by the specific gravity of water; the product will be the weight of a quantity of water of equal bulk with the cask.

2nd. From this product, or weight, subtract the weight of the cask, and the remainder will be the weight it will support without sinking. *Then by Proportion*, the number required for the formation of the raft may be found.

3. *To find the number of boats, or pontoons, required to support a given weight.*

The burthen a boat, or pontoon, will support without sinking beyond a given depth (the form of the boat, or pontoon, being known) must first be found, thus—

1st. Find the solid content of the part to be sunk, in cubic feet (*vide* PRACTICAL GEOMETRY, *Part* 13), and multiply it by the specific gravity of water (*vide* GRAVITY, *Part* 13).

2nd. Subtract from this product the weight of the boat, or pontoon, and the remainder will be the burthen it will support without sinking beyond the required depth.

Then by Proportion, the number required to support the given weight may be computed.

Note.—In the construction of Bridges, should a rope require to be extended across a rapid river, the coil should be placed in the boat, and be paid out to the shore, as the boat advances.

PONTOONS.

General Blanchard's, Admiral Caffin's pattern.—These Pontoons are cylindrical, and are formed of sheet iron in two pieces, which are bolted together for convenience of transport, &c.; the interior being strengthened with ribs of angle iron.

Dimensions, and Weight.

	Extreme Length.		Diameter.		Weight.
	ft.	in.	ft.	in.	cwt.
Heavy, or Cavalry, with Hemispherical ends	22	6	2	7	5¼
Light, or Infantry, with Conical ends	15	4	1	7	1¼

PART XII.

FIREWORKS.

CASES.

CASES are made of different dimensions according to the description of firework required, and the length of time it is intended to burn.

The following is a description of the method generally adopted in making cases.

The "Former" is a cylinder of such size as may be required, of wood, solid brass, or brass tubing: the last is to be preferred on account of its lightness, and non-liability to alter its shape like wood.

The paper used is good strong brown paper, weighing not less than 84 lb. to the ream—cut up into slips, the width of paper corresponding to the length of the case. As the paper is always tougher in one direction than the other, care must be taken to cut it so as to roll up in the direction in which the paper is tough.

A slab of slate, about 18 inches wide and 4 feet long, with a polished surface, is generally used to roll the paper upon, and a wooden board with a handle at the back is required to press the layers of paper together after the paper has been rolled.

To roll a case.—Place the piece of paper on the slab, paste over the whole of the upper surface; then lay the former upon the paper close to the bottom edge, and parallel to it. Roll up tightly to the top, using as many slips of paper as is necessary for the thickness of the case. Press down the wooden board upon the case, and former, rolling it forward, until the layers of paper adhere closely, and the case is of the proper gauge. Slip the case off the former.

If required for a rocket, or other contracted case, it must then be choked with a strong piece of cord until the vent is reduced to the size of the spindle that will be used when the case is driven.

ROMAN CANDLES.

When the case has been properly finished, ram in a little dry clay, then put in a small quantity of grain powder, then a star, after which a ladleful of composition is to be put in, and lightly rammed down. Repeat this operation with the powder, star, and composition till the case is filled, after which it must be primed, and capped.

The ladle used for this, and all other cases ought to be two diameters and a half in length, and a little less than half a diameter in height, so as to admit of its entering the case.

Roman candles fired alone are generally placed upright in rows, but when used in connection with a fixed piece, they may be fired at any inclination, not exceeding 45°.

Signal rocket composition, with about 4 oz. of mealed powder to the proportion hereafter given, makes about the best composition for Roman candles.

The signal rocket stars are also the best for Roman candles; they ought to be just of such size as to drop readily to the bottom of the case.

CRACKERS.

The case is made of cartridge paper, the dimensions required being 15 inches by 3½ inches. First fold down one edge, about ¾ of an inch broad, then turn down the double edge about ¼ of an inch, and bend back the single edge over the double fold, so as to form within a channel, which is to be filled with mealed powder, not ground very fine; the powder is then to be covered by the folds on each side, and the whole is to be pressed by a flat ruler; and the part containing the powder is to be folded into the remainder of the paper, every fold being pressed down. The cracker is then doubled backwards, and forwards in folds about 2½ inches, which are pressed quite close, and a piece of twine is passed twice round the middle across the folds, and the joinings secured by causing the twine to take a turn round the middle at each fold successively; one of the ends of the folds may be doubled short under, which will produce an extra report; the other must project a little beyond the rest for the purpose of being primed.

EARTHQUAKE, ARTIFICIAL.

Mix together twenty pounds of iron sand, and twenty pounds of sulphur; and after making it into a paste with water, bury it a little depth in the ground. In ten or twelve hours, if the weather be warm, the earth will swell up, and burst; flames will also issue out, scattering around a yellow and black dust.

GERBES.

Gerbes consist of strong cylindrical choked cases of thick paper, filled with brilliant composition, and sometimes with balls or stars. Gerbes throw up into the air luminous and sparkling jets of fire; and when arranged in a circular manner, as the radii of a circle, they form what is called a fixed sun. The thickness of the cases for brilliant fire must be a fourth part of the diameter, and for Chinese fire a sixth part. The case is loaded on a nipple, having a point equal in length to the same diameter, and in thickness to a fourth part of it; but as it generally happens that the mouth of the jet becomes larger than is necessary for the effect of the fire, the case should be first charged by filling it to a height equal to a fourth part of the diameter, with clay, which must be rammed down. When clay has been thus used, care must be taken to clear it out at the top of the hollow left by the spindle. When

the charge is completed with the composition, the case should be closed with about two drams of powder, and then choked. The train, or match, must be of the same composition as that employed for loading, otherwise the jet would be subject to burst. Jets intended for representing sheets of fire ought not to be choked. They must be placed in a horizontal position, or inclining a little downwards.

Composition for Gerbes, or jets of fire.

JETS.		Saltpetre.	Mealed powder.	Sulphur.	Charcoal.	Iron sand, or filings.
		lb. oz.	lb. oz.	oz.	oz.	oz.
·4 of an inch or less interior diameter . .	Chinese fire	1	1	8	2	
	White fire .	1	8	3	2	Sand, 1st order 8
·5 to 1 inch diameter . .	Brilliant fire		1			Filings . . . 5
	White fire .	1		8	2	
	Chinese fire	1 4		5	5	Sand, 3rd order 12
1·1 to 1·5 diameter . .		1 4		7	5	Mixed Sand .12
			1 8		5	
		2	2		8	
Any case to ½ lb. . . .	Chinese fire .	12	1 2	6	4	Iron borings .10

The saltpetre, powder, and charcoal, are three times sifted through a hair sieve. The iron filings are preserved from the deterioration, which would result from the presence of sulphur, by coating them with marine glue. This is done by cutting up 2 oz. of marine glue into small pieces, and melting it in a pan with 1 lb. of iron filings.

They are then added to the other ingredients, and the whole mixed by hand, or with a brush.

The composition is put in by ladlesful; the first two ought to be of charcoal 2 oz., mealed powder 1 lb., and driven with a mallet and drift, 15 blows to each ladleful of composition.

All mallets, and drifts used for fireworks should be made of boxwood.

IRON SAND, OR POUNDED IRON.

Having broken a cast-iron plate, or iron pot, to pieces, on an anvil, pulverize the fragments till the grains are not larger than radish seed, *then sift* them through six graduated sieves to separate the different *sizes;* and preserve these six different kinds in a very dry place in closely-corked bottles. The grains which pass through the first or

finest sieve, are called *Sand of the 1st order*, and those that pass through the second sieve, *Sand of the 2nd order*, &c.

Cast-iron borings are well adapted for this purpose.

LEADERS, OR PIPES OF COMMUNICATION.

These are small tubes of paper, of lengths adapted to the distances to which they are to extend. The paper is cut into slips two or three inches broad, or sufficient to go four times round the formers, which are about one-fourth of an inch diameter. Brass wire formers are the best, and should be oiled to prevent the paper sticking. Quick match is inserted in these tubes, but must be made to go in easily. The quick match should project an inch beyond each end of the leader, and should be inserted into the mouths of the cases of the fireworks with a small quantity of mealed powder. The leaders must not be placed too near, or cross each other so as to touch, as it may happen that the fire from one may communicate to another, and destroy thereby the intended arrangements.

MARROONS.

Marroons are boxes containing from 1 to 6 ounces of powder. They are made either on a square or round former, and the ends of the paper are pasted down, and well welded round with knitted twine worked over cross-ways. A hole is bored into the case, and a match inserted.

MEALING GUNPOWDER.

A small quantity of powder being placed on a table with a rim round it, is rubbed down with a scored wooden mealer until all the grains are broken, and it becomes sufficiently fine to pass through a lawn sieve. Or, it may be beaten in a strong leather bag with wooden mauls: or, ground in a revolving drum with copper balls; projecting ribs being constructed in the interior of the drum, and covered with leather.

PORTFIRES FOR ILLUMINATIONS; OR SPECKIE OF LANCES.

The cases are made of three or four rounds of demy paper, the last round being pasted; they are from two to five-eighths of an inch in diameter, and from two to six inches long; they are pinched close at one end, and left open at the other. In filling them, a small quantity of the composition must be put in at a time, ramming it lightly, so as not to break the case.

The composition should be inserted by means of a funnel and wire; the wire being moved up and down in the case admits a small quantity at a time through the neck of the funnel, and presses it gently down.

Brilliant, and diversified displays of fireworks may be readily exhibited by means of speckie of lances. Illuminated designs of figures, &c., are represented by affixing on a black board small cases filled with various coloured compositions, to which leaders must be

attached. The cases are fastened on with glue, and red lead mixed together.

Compositions.

							White.		Yellow.		Blue.		Yellow.	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
Saltpetre	1		6		2		2	4		8	1	2	1	
Sulphur		8	2		3			8	1			4		8
Mealed powder . .		6	1					4		12				10
Antimony, crude .			1		1			4						
Gum Succum . .										8				
Antimony, prepared												8		
Basket salt . . .														6

Stars, crosses, revolving suns, &c., being formed on the wooden frame with the speckie, will form a brilliant display.

RAIN, GOLD, AND SILVER.

Fill small paper cases, the same as cases for lances, with the composition, and place upon the mouth of each some moist powder, both to keep in the composition, and to serve as a match. If the head of a rocket be loaded with these cases, or quills, a shower of fiery rain will be produced at the extreme range of the rocket.

Compositions.

Gold Rain.

1. Mealed powder, 12 oz.; saltpetre, 2 oz.; charcoal, 4 oz.
2. Saltpetre, 8 oz.; sulphur, 4 oz.; mealed powder, 12 oz.; charcoal, 5 oz.

Silver Rain.

1. Saltpetre, 4 oz.; sulphur, mealed powder, and antimony, each 2 oz.; sal prunella, ½ oz.
2. Saltpetre, 8 oz.; sulphur, 2 oz.; charcoal, 4 oz.
3. Saltpetre, 1 lb.; antimony, 6 oz.; sulphur, 4 oz.
4. Saltpetre, 4 oz.; sulphur, 1 oz.; powder, 2 oz.; steel dust, ¾ oz.

ROCKETS, LINE.

Any rocket, which is not very large, may be made to run along an extended rope. For this purpose affix to the rocket an empty case, and introduce therein the rope which is to carry it, placing the head of the rocket towards that side to which it is intended to move. Two rockets with an empty case may be similarly used, and may be made to move in a retrograde direction by placing them with their heads reversed, and

a leader to communicate from the head of the rocket to be first ignited to the tail of the second.

ROCKETS, SIGNAL.

Composition.

Pulverized saltpetre, 4 lb.; sublimed sulphur, 1 lb.; dogwood charcoal, 1 lb. 12 oz.

The charcoal is first pounded fine enough to pass through a wire sieve, 36 meshes to the inch. The saltpetre, and sulphur are each separately passed through a fine hair sieve, then mixed well together with a copper slice, and passed three times through the hair sieve. The charcoal is then spread on a tray, and the saltpetre, and sulphur sifted a fourth time on it, and the whole being carefully mixed with a hard brush, is afterwards passed four times through the wire sieve.

To each ladleful of composition, 25 blows are given for the pound, and 21 for the half-pound rocket.

Twenty-eight ladlefuls of composition (7½ oz.) are required to complete the pound, and twenty-five (5 oz.) the half-pound rocket.

To prevent accidents in driving rockets, &c., the workman should keep his body erect, the drift being well cleaned after each ladleful; and while driving, it should be moved backward, and forward by a pair of holders.

Rockets are driven 3½ calibres hollow, 1 calibre solid, and ½ calibre with clay.

Moulds.

		Length.	Diameter.
1 Pounder	Exterior	14 inches	3·9
	Interior	10·5 „	1·7
½ Pounder	Exterior	11·6 „	2·3
	Interior	8·5 „	1·3

Spindles.

	Diameter. Top.	Middle.	Bottom.	Length.
1 Pounder	·2	·35	·5	6·4
½ Pounder	·2	·3	·4	5·2

Drifts.

	Length.	Diameter.	Hollowed.	No.
1 Pounder	12·1 inches	1·1	6·5	1
	10 „	1·1	5·7	2
	7·3 „	1·1	2·5	3
	6·8 „	1·1	Solid	4
½ Pounder	9·3 „	·9	5·4	1
	7·1 „	·9	2·3	2
	4 „	·9	Solid	3

The rocket is primed with mealed powder, and spirits of wine.

When *complete*, the length of the pound rocket is 15½ inches; and

the half-pound 12 inches; the weight of the pound rocket and stick is 1¾ lb.; and the half-pound, 13 oz.

Length of sticks for rockets.

1-Pounder rocket . .	8 feet	Half-pounder . .	6 feet 4 inches.

Star compositions.

No. 1.

Saltpetre, pulverized . .	8 lb.	Isinglass, dissolved .	3½ oz.
Sulphur, sublimated . .	2 lb.	Vinegar	1 quart.
Antimony, pounded . .	2 lb.	Spirits of wine . .	1 pint.

2. *White stars.* Mealed powder, 4 oz.; saltpetre, 12 oz.; sulphur vivum, 6 oz.; oil of spike, 2 oz.; camphor, 5 oz.

3. *Blue stars.* Mealed powder, 8 oz.; saltpetre, 4 oz.; sulphur, 2 oz.; spirits of wine, 2 oz.; oil of spike, 2 oz.

4. *Brilliant stars.* Saltpetre, 3½ oz.; sulphur, 1½ oz.; mealed powder, ¾ oz., worked up with spirits of wine.

5. *Common stars.* Saltpetre, 1 lb.; sulphur, 4 oz.; antimony, 4¾ oz.; isinglass, ½ oz.; camphor, ½ oz.; spirits of wine, ¾ oz.

6. *Tailed stars.* Mealed powder, 3 oz.; sulphur, 2 oz.; saltpetre, 1 oz.; charcoal, coarsely ground, ¾ oz.

7. *Drove stars.* Saltpetre, 1 lb.; antimony, 4 oz.; sulphur, 8 oz.

8. *Fixed pointed stars.* Saltpetre, 8½ oz.; sulphur, 2 oz.; antimony, 1 oz. 10 drs.

The dry ingredients are well mixed, and sifted through a hair sieve: the isinglass dissolved over a fire with vinegar, and the spirits of wine afterwards added, and with which the dry composition is thoroughly mixed. It is then formed on moulds, and a hole is left in the middle to assist its ignition. Thirty-six stars are put in a 1-pounder, and twenty-two in a half-pounder rocket.

A great variety of figures may be represented in the air by attaching to a large rocket several small rockets, or small cases filled with the composition; or serpents may be attached to the rocket by means of packthread.

SALTPETRE, PULVERIZED.

Sixteen pounds of refined lakepetre are put into a copper vessel, to which four quarts of water are added. It is placed over a charcoal fire to boil; as the water evaporates it is well stirred with copper-shod spatulas, or paddles, occasionally taking it off the fire until the evaporation ceases; and when brought to a fine powder it is sifted through a hair sieve, and spread on paper to cool.

To extract saltpetre from damaged gunpowder.

Dissolve the powder in warm water, filter the solution through fine linen bags, and then evaporate the water by boiling it, until the solution is of sufficient strength to crystallize.

SERPENTS, OR SQUIBS.

The case is made by rolling stout cartridge paper in slips of 6 or 8 inches in breadth three times round a former, and pasting down the last fold. The case, having been choked at one end, is filled about two-thirds with the composition, and a small piece of paper is inserted, over which powder is placed, and this end is secured with twine. At the other extremity, moist powder with touch-paper is inserted. To introduce the composition into the case, a funnel, and wire are used, the wire being pressed hard down upon the composition.

Composition.

	1. lb.	oz.	2. lb.	oz.	3. lb.	oz.
Mealed powder	1	8	1	0	1	0
Charcoal		4		1		12
Sulphur		1		.		
Saltpetre		3		$1\frac{3}{4}$		

SHELLS, OR AERIAL GLOBES.

These globes are made of wood, and their thickness is equal to about a twelfth part of their diameters. The usual charge is an ounce of powder for a shell of 4 lb. weight, and 2 ounces for a shell of 8 lb. They may be fired from any mortars that have not a chamber.

To form the shell.

Two wooden hemispheres (with a fuze hole) are joined firmly together, enclosing stars, squibs, rain, &c. A small quantity of powder is inserted to explode the shell, by means of a fuze.

SHOWERS OF FIRE, OR CASCADES.

Make a case $\frac{1}{2}$ an inch in diameter, the thickness of paper being about $\frac{1}{8}$th of an inch. Stop up one end with clay. Drive it with the composition firmly with a drift and mallet, a ladleful at a time. These cases must be fixed on a frame with leaders, to be fired simultaneously.

Compositions.

Chinese fire. Mealed powder, 1 lb.; saltpetre, 2 oz.; iron filings, very fine, 8 oz.; charcoal, very fine, 5 oz.

Ancient fire. Mealed powder, 1 lb.; charcoal, 2 oz.

Brilliant fire. Mealed powder, 1 lb.; iron filings, 4 oz.

The Chinese fire is the best of the above compositions.

The charcoal, and iron filings ought to pass through a 60 mesh sieve.

SPUR FIRE.

Compositions.

	1. lb.	oz.	2. lb.	oz.
Saltpetre	4	8	1	8
Sulphur	2	0		8
Lamp black	1	8		8

The saltpetre, and sulphur must be first sifted together, and then put into a marble mortar with the lampblack. These ingredients must be thoroughly mixed with a wooden pestle. The composition, if rubbed too much, will be too fierce, and hardly show any stars; and on the contrary, when not mixed enough, will be too weak, and throw out an obscure smoke, and lumps of dross without any stars. This composition is generally rammed in 1, or 2 ounce cases, about five, or six inches long, but not driven very hard. Cases filled with spur fire may be used in rooms without any danger of setting fire to the flooring, and some of them being placed round a transparent pyramid of paper, and fired in a large room, make a very pretty appearance.

SUNS, OR WHEELS, FIXED AND MOVEABLE.

None of the pyrotechnic inventions can be applied with so much success in artificial fireworks, as suns, or wheels, of which there are two kinds, fixed, and revolving.

FIXED SUNS.

Construct a circular piece of wood, into the circumference of which screw 12 or 15 pieces in the form of radii, and to these attach jets of fire, the mouth of each of which must be towards the circumference of the frame; and leaders being affixed to all the jets, they will, when ignited, produce the appearance of a radiated sun. The wheel is fixed vertically. The jets may be arranged so as to cross each other in an angular manner, in which case a *star*, or *cross of Malta* will be formed. To produce a very brilliant effect, these suns may be made with several rows of jets.

REVOLVING SUNS.

Provide a wooden wheel of the requisite size, and bring it into perfect equilibrium round its centre, in order that the least effort may make it turn round. Attach to the circumference of it jets placed in the direction of the circumference; and affix leaders of match to communicate the fire from jet to jet, according as may be required. When fire is applied to one of the jets, the recoil will immediately cause the wheel to revolve, unless it should be too ponderous or large: therefore, when these suns are intended to be of a considerable size, that is, when they consist of twenty jets, fire must be communicated at the same time to the 1st, 6th, 11th, and 16th, from which it will proceed to the 2nd, 7th, 12th, and 17th, and so on. Four jets will thus make the wheel revolve rapidly. If two similar suns be placed one behind the other, and be made to turn round in a contrary direction, they will produce a very brilliant cross fire.

For a sun 5 feet in diameter, the cases should be 8 oz., filled about 10 inches in length with composition.

Compositions.

Slow fire.

	oz.
Saltpetre.	4
Sulphur	2
Mealed powder . .	1¼

Dead fire.

	oz.
Saltpetre. . . .	1¼
Sulphur	¼
Lapis Calemanaris .	¼
Antimony . . .	⅛

Brilliant fire.

	lb.	oz.
Mealed powder.	6	0
Saltpetre. . .		8
Sulphur . . .		2
Iron sand . .		12

Illumination fire.

	lb.	oz.
Saltpetre. . .	1	0
Sulphur . . .		8
Mealed powder.		6

Golden colour.

	lb.	oz.
Mealed powder.	1	0
Charcoal, very good		2

Red Chinese fire.

	lb.	oz.
Mealed powder.	1	0
Saltpetre. . .	1	0
Charcoal . . .		4
Sulphur . . .		4
Iron sand, 2nd and 3rd order		14

White Chinese fire.

	lb.	oz.
Mealed powder	1	0
Saltpetre	1	0
Sulphur		8
Iron sand, 2nd & 3rd order		14

Grey colour.

	lb.	oz.
Mealed powder. . . .	1	0
Saltpetre.		4
Sulphur.		2
Charcoal.		1½

Four ounce cases will be required for wheels of 14, or 16 inches; if the wheels are larger, 8 oz., 1 lb., or even 2 lb. cases will be required.

The Chinese compositions are intended for cases of nine-tenths of an inch interior diameter, but they will be found to answer for cases as low as four ounces.

TOUCH PAPER.

Dissolve saltpetre in water; more or less of the saltpetre, according as the paper is to burn fast, or slow: then dip into the solution blue paper, which, when well saturated, take out, and dry for use. The touch paper must be cut into slips, placed once round the mouth of the firework, and the end of the paper outside the case should be twisted to a point.

WHEELS, PIN, OR CATHERINE.

The pipe, or case is made on a long wire former, about three-sixteenths of an inch in diameter, into which the composition is poured through a funnel, and shaken down. The case is then rolled round a small circle of wood about one inch in diameter, and not more than half an inch thick, with a hole through the centre of it for a nail, or pin. One end of the case is to be pasted round the wood, and each half turn of it secured with sealing-wax, or a strip of paper pasted across the wheel. The end is then primed.

Composition.

Mealed powder, 12 oz.; saltpetre, 3 oz.; sulphur, 1½ oz.

Two ounces of iron sand, or camphor, may be added, but it keeps better without either.

PART XIII.

MATHEMATICS.

Mathematics is the science which treats of all kinds of quantity whatever, that can be numbered, or measured.

Arithmetic is that part which treats of numbering.

Fractions treat of broken numbers, or parts of numbers.

Algebra is the art of computing by symbols.

In this science, quantities of all kinds are represented by the letters of the alphabet.

Geometry is the science relating to measurement. By the assistance of geometry, engineers, &c., conduct all their works, take the distances of places, and the measure of inaccessible objects, &c.

Characters, marks, or signs, which are used in arithmetic, and algebra, to denote several of the operations, and propositions:

$+$ *signifies* plus or addition, $-$ minus, or subtraction,
$\times$,, multiplication, $\div$ division,
$: \; : : \; :$ proportion, $=$ equality, $\surd$ square root,
$\sqrt[3]{}$ cube root, 4^2 *denotes that* 4 is to be squared.
4^3 *denotes that* 4 is to be cubed.

TABLES OF WEIGHTS, AND MEASURES.

TROY WEIGHT.

24 grains .	1 pennyweight.		
480 . . .	20	1 ounce.	
5760 . . .	240	12	1 pound.

AVOIRDUPOIS WEIGHT.

16 drams	1 ounce.				
256 . .	16 . .	1 pound.			
7168 . .	448 . .	28 . .	1 quarter.		
28672 .	1792 .	112 . .	4 . .	1 hundred weight.	
573440 .	35840 .	2240 . .	80 . .	20 . . .	1 ton.

Note.—14 pounds = 1 stone; 2 stones = 1 quarter.

1 lb. Avoirdupois weight = 14 oz. 11 dwts. 15½ grs. Troy.
1 oz. ditto . . . . = . . 18 dwts. 5½ do.
1 dr. ditto . . . . = . . 27·34375 do.

APOTHECARIES' WEIGHT.

20 grains	1 scruple.			
60	3	1 dram.		
480	24	8	1 ounce.	
5760	288	96	12	1 pound.

WEIGHTS.

To find the weight, for tonnage.

Cattle—

Divide the number by 3, for weight in tons.

Sheep . . . Average 60 lb. each.

Divide by 33, for weight in tons.

Pigs . . . Average 80 lb.

Divide by 15, for tons.

Beer, or Ale—

Barrel . . . . . . $3\frac{1}{4}$ cwt.

Hogshead . . . . . $5\frac{1}{4}$ cwt.

Oats . . . Sack . . . . 24 stone.

Divide quarters by 5, for tons.

Rum—

Divide gallons by 224, for tons.

Wine . . Cask. . . . . 12 cwt.

HAY, AND STRAW.

1 load	36 trusses.
1 truss of old Hay	56 pounds.
1 load of do. do.	18 hundred weight.
1 truss of new Hay	60 pounds.
1 load of do. do.	19 cwt. 32 lb.
1 truss of Straw	36 pounds.
1 load of do.	11 cwt. 64 lb.
1 cubic yard of New Hay weighs	6 stone.
1 Do. of Oldish do.	8 do.
1 Do. of Old do.	9 do.

Rule for ascertaining the weight of Hay.

Measure the length, and breadth of the stack; then take its height from the ground to the eaves, and add to this last one-third of the height from the eaves to the top: Multiply the length by the breadth, and the product by the height, all expressed in feet; divide the amount by 27, to find the cubic yards, which multiply by the number of stones supposed to be in a cubic yard, and you have the weight in stones. (*Vide* foregoing Table.) For example, suppose a stack to be 60 feet in length, 30 in breadth, 12 in height from the ground to the eaves, and 9 (the third of which is three) from the eaves to the top; then $60 \times 30 \times 15 = 27000$; $27000 \div 27 = 1000$; and $1000 \times 9 = 9000$ *stones of old hay.*

LONG MEASURE.

12 inches	1 foot.				
36 . .	3 . .	1 yard.			
198 . .	$16\frac{1}{2}$ . .	$5\frac{1}{2}$ . .	1 pole, perch, or rod.		
7920 . .	660 .	.220 . .	40 . .	1 furlong.	
63360 . .	5280 .	1760 . .	320 . .	8. . .	1 mile.

LAND MEASURE (*Length*).

7·92 inches	1 link.
100 links, or 22 yards . . .	1 chain.
80 chains	1 mile.
69·121 miles	1 geographical degree.

LAND MEASURE (*Surface, or Superficial*).

62·7264 square inches	1 square link.
625 square links	1 square pole, or perch.
10000 square links	1 square chain.
2500 square links	1 square rood, or pole.
10 square chains	1 square acre.
100000 square links	1 square acre.

NAUTICAL MEASURE.

1 nautical mile	6082·66 feet.
3 miles	1 league.
20 leagues	1 degree.
360 degrees	the earth's circumference.

SQUARE MEASURE.

144 s. inches	1 s. foot.				
1296 . . .	. 9 . .	1 s. yard.			
39204 . .	$272\frac{1}{4}$. .	$30\frac{1}{4}$ . .	1 s. pole.		
1568160 .	.10890 .	1210 . .	40 . .	1 rood.	
6272640 .	.43560 .	4840 .	.160 . .	4 . .	1 acre.

CUBIC MEASURE (*Measure of solidity*).

1728 cubic inches	1 cubic foot.
27 cubic feet	1 cubic yard.

Note.—A cubic foot is equal to 2200 cylindrical inches, or 3300 spherical inches, or 6600 conical inches.

Timber.

40 feet of round, and 50 feet of hewn timber make 1 *Ton*; 16 cubic feet make 1 *Foot* of wood; 8 feet of wood make 1 *Cord*.

Water.

Maximum density 42 deg. Fahrenheit.

1 cubic foot of water	$6\frac{1}{4}$ imperial gallons.
1 cylindric foot do.	about 5 do.

1 cubic foot	weighs	62·5	lb. avoirdupois.
1 cylindric do.	do.	49·1	
1 lineal do. (1 inch square)	do.	·434	
12·2 imperial gallons	weigh	1 cwt.	
224 do.	do.	1 ton.	
1·8 cubic feet	do.	1 cwt.	
35·84 do.	do.	1 ton.	

MEASURES OF CAPACITY.

69⅓ cubic in.	2 pints	1 quart.				
277¼	8	4	1 gallon.			
554½	16	8	2	1 peck.		
2218⅕	64	32	8	4	1 bushel.	
10¼ cubic ft.	512	256	64	32	8	1 quarter.

FRENCH MEASURES.

	English cubic inches.
Millilitre	·06103
Centilitre	·61028
Decilitre	6·10279
Litre, or cubic decimetre	61·02791
Decalitre	610·27900
Hectolitre	6102·79000
Kylolitre	61027·90000
Myrialitre	610279·00000

1 litre is nearly 2⅛ wine pints.
1 kilolitre 1 tun 12¾ wine gallons.
1 stere, or cubic metre . 35·3171

	English feet.
Metre	3·281
„ French feet, 3·07844	
Millimetre	·03937
Centimetre	·39371
Decimetre	3·93708
Metre	39·37079
Decametre	393·70790
Hectometre	3937·07900
Kilometre	39370·79000
Myriametre	393707·90000

8 kilometres are nearly 5 miles.
1 inch is ·0254 metre.
100 feet are nearly 30·5 metres.

FRENCH WEIGHTS.

The *gramme* is the unit, equal to 15·44 *Grains, Troy measure.*

1 Milligramme = ·0154 grain.
1 Centigramme = 10 milligrammes.
1 Décigramme = 10 centigrammes.
1 Gramme = 10 decigrammes.
1 Decagramme = 10 grammes.
1 Hectogramme = 10 decagrammes.
1 Kilogramme = 10 hectogrammes.
1 Myriagramme = 10 kilogrammes.
1 Quintal = 10 myriagrammes.
1 Millier or bar = 100 quintals = 19 tons, 16 cwt., 3 qrs., 12¼ lbs.

Note.—The livre usuel = 500 grammes; the once = 31·3 grammes = 1 oz. 1¾ drs.; the ponce = 2·77 centimètres; the pied = 3·33 décimètres; the aune = 12 décimètres; the toise = 2 metrès; the litron usuel = 62·45 English cubic inches. Deca means 10 times, and Deci $\frac{1}{10}$th of; hecto, 100 times, and centi $\frac{1}{100}$th of; kilo, 1000 times, and mille $\frac{1}{1000}$th of; myria means 10,000 times.

ARITHMETIC.

REDUCTION.

Reduction is the method of converting numbers from one name, or denomination to another: or the method of finding the value of a quantity in terms of some other higher, or lower quantity.

To reduce from a higher to a lower denomination.

Rule.—Multiply the given number by as many of the lower denomination as make one of the greater;* adding to the product as many of the lower denomination as are expressed in the given sum.

* *Vide Tables of Weights, and Measures.*

Example.—In £6 15*s.* 5*d.*, how many pence?

```
£.  s.  d.
6   15  5
20
----
135
12
----
1625 Answer.
```

To convert from a lower to a higher denomination.

Rule.—Divide the given number by as many of the lower denomination as are required to make one of the greater.* Should there be any remainder, it will be of the same denomination as the dividend.

* *Vide Tables of Weights, and Measures.*

Example. — Convert 1625 pence into pounds, shillings, and pence.

```
 12)  1625 pence
      ----
2/0)  13/5  5
      --------
£6 15s. 5d. Answer.
```

THE RULE OF THREE, OR SIMPLE PROPORTION.

It is called the *Rule of Three* because three numbers are given to find a fourth. It is also called *Simple Proportion*, because the 1st term bears the same proportion to the 2nd, as the 3rd does to the 4th. Of the three given numbers, two of them are always of the same kind, or name, and are to be the 1st, and 2nd terms of the question; the 3rd number is always of the same name, or kind as the 4th, or answer sought; and in stating the question it is always to be made the 3rd term. If the answer will be *greater* than the 3rd term, place the least of the other two given quantities for the 1st term; but if the answer will be *less* than the 3rd term, put the greater of the two numbers, or quantities, for the 1st term.

Rule.—State the question according to the above directions, and *multiply* the 2nd and 3rd terms together, and divide this product by *the 1st*, for the 4th term, or answer sought.

If the 1st and 2nd terms are not of the same denomination, they

must be reduced to it; and if the third term is a compound number it must be reduced to its lowest denomination before the multiplication, or division of the term takes place.

Note 1.—The operation may frequently be considerably abridged, by dividing the 1st and 2nd, or the 1st and 3rd terms, by any number which will exactly divide them, afterwards using the quotients, instead of the numbers themselves.*

Example.—If 2 tons of iron for ordnance cost £40, how many tons may be bought for £360?

As £40 : £360 : : 2 tons : 18 tons.
(Thus $360 \times 2) \div 40 = 18$. The Answer.

* Or thus $9 \times 2 = 18$. The Answer.

Note 2.—*A concise method of ascertaining the Annual amount of a daily sum of money.*

Rule.—Bring the daily sum into pence, and then add together as many pounds, half pounds, groats and pence, as there are pence in the daily sum, for the amount required. For leap year, add the rate for one day.

Example.—Required the annual amount of 2*s*. 6*d*. per diem.

		£.	*s*.	*d*.
2*s*. 6*d*. = 30*d*.	30 pounds . . .	30	0	0
	30 half pounds . .	15	0	0
	30 groats . . .	0	10	0
	30 pence	0	2	6
	Annual amount (365) days	£45	12	6

Note 3.—To find the amount of any number of days' pay, the daily rate (under twenty shillings) being given.

The price of any article being given, the value of any number may be ascertained in a similar manner.

Rule 1. When the rate (or price) is an even number, multiply the given number by half of the rate; double the first figure to the right hand for the shillings, the remainder of the product will be pounds.

Rule 2. When the price is an odd number, find for the greatest number as before, to which add one-twentieth of the given number for the odd shilling.

Example. Required the amount of 243 days' pay, at 4*s*. per diem.

$\frac{4}{2} = 2$ 243
2
————
£48 12*s*. *Answer*.

Example. What is the price of 566 pairs of shoes, at 7*s*. per pair.

566   2/0) 56/6
3   ———
———   28 6
169 16*s*.
28 6
————
£198 2*s*. Answer.

FRACTIONS.

A fraction is a quantity which expresses a part, or parts of a unit, or integer. It is denoted by two numbers placed with a line between them.

A simple fraction consists of two numbers, called the numerator and denominator; thus, 3 numerator.

—

5 denominator.

The Denominator is placed below the numerator, and expresses the number of equal parts into which the integer is divided.

The Numerator expresses the number of parts of the broken unit, or integer; or shows how many of the parts of the unit are expressed by a fraction.

A Compound fraction is a fraction of a fraction, as $\frac{3}{5}$ of $\frac{4}{5}$.

A Mixed number consists of a whole number with a fraction annexed to it, as $4\frac{3}{5}$.

An Improper fraction has the numerator greater than the denominator, as $\frac{6}{5}$.

REDUCTION OF FRACTIONS

is bringing them from one denomination to another.

To reduce a fraction to its lowest terms.

Rule.—Divide the numerator, and the denominator, by any number that exactly divides them, and the quotients by any other number, till they can be no longer divided by any whole number, when the fraction will be in its lowest terms.

Example.—Reduce $\frac{4032}{6048}$ to its lowest terms.

Thus, $\frac{\overset{4}{4032}}{6048} = \frac{\overset{12}{1008}}{1512} = \frac{\overset{6}{84}}{126} = \frac{\overset{7}{14}}{21} = \frac{2}{3}$. *Answer.*

To reduce an improper fraction to a whole, or mixed number.

Rule.—Divide the numerator by the denominator, the quotient will be the whole number; and the remainder (if any) the numerator of the fraction, having the divisor for the denominator.

Example.—Reduce $\frac{114}{12}$ to a whole, or mixed number.

$$12)114$$

$$9\frac{6}{12}$$ *Answer.*

To reduce a mixed number to an improper fraction.

Rule.—Multiply the whole number by the denominator, and add the numerator to the product, under which place the given denominator.

Example.—Reduce $17\frac{5}{8}$ to an improper fraction.

$$\begin{array}{r} 17\frac{5}{8} \\ 8 \\ \hline 141 \end{array}$$

$\frac{141}{8}$ Answer.

To reduce a compound fraction to a simple fraction.

Rule.—Multiply all the numerators together for the numerator, and all the denominators for the denominator.

Example.—Reduce $\frac{3}{8}$ of $\frac{1}{6}$ of $\frac{1}{2}$ of 9 to a simple fraction.

$$\begin{array}{ll} \text{Numerators} & \dfrac{3\times1\times1\times9}{8\times6\times2\times1} = \dfrac{27}{96} = \dfrac{9}{32} \; \textit{Answer.} \\ \text{Denominators} & \end{array}$$

To reduce fractions of different denominators to equivalent fractions, having a common denominator.

Rule.—Multiply each numerator by all the denominators except its own for the new numerator, and multiply all the denominators together, bringing them to a common denominator.*

Example.—Reduce $\frac{3}{8}$, $\frac{2}{3}$, and $\frac{4}{5}$ to fractions, having a common denominator.

$$\begin{array}{l} 3\times3\times5=\ 45 \\ 2\times8\times5=\ 80 \\ 4\times8\times3=\ 96 \\ 8\times3\times5=120 \quad \textit{Answer, } \frac{45}{120}, \frac{80}{120}, \text{ and } \frac{96}{120}. \end{array}$$

ADDITION OF FRACTIONS.

Rule.—Bring compound fractions to simple fractions; reduce all the fractions to a common denominator, then add all the numerators together, and place their sum over the common denominator. When mixed numbers are given, find the sum of the fractions, to which add the whole numbers.

Example.—Add together $\frac{5}{6}$, $\frac{3}{4}$, and $6\frac{1}{2}$.

$$\begin{array}{ll} 5\times4\times2=40 & \\ 3\times6\times2=36 & \frac{40}{48}+\frac{36}{48}+\frac{24}{48}+6=8\frac{4}{48}. \\ 1\times6\times4=24 & \text{or, by cancelling, and dividing,}\dagger \\ 6\times4\times2=48 & \frac{10}{12}+\frac{9}{12}+\frac{6}{12}+6=8\frac{1}{12}. \quad \textit{Answer.} \end{array}$$

SUBTRACTION OF FRACTIONS.

Rule.—Prepare the quantities, as in addition of fractions. Place the less quantity under the greater. Subtract the lower numerator from the upper; under the remainder write the common denominator, and, if there be whole numbers, find their difference as in simple subtraction.

$$\begin{array}{rll} \textit{Example.}\text{—From} & 54\frac{5}{6} & \text{or } 54\frac{25}{30} \\ \text{Take} & 25\frac{5}{15} & \text{or } 25\frac{10}{30} \\ \hline & 29\frac{15}{30} & \text{or } 29\frac{1}{2}. \quad \textit{Answer.} \end{array}$$

* In reducing fractions to a common denominator, and in multiplication of fractions, the work may be considerably diminished by cancelling any figures, which are in all the multiples; or by dividing a figure in each of them by any figure which can divide all without any remainder.

† See *Note, above.*

MULTIPLICATION OF FRACTIONS.

Rule.—Reduce mixed numbers to equivalent fractions; then multiply all the numerators together for a numerator, and all the denominators together for a denominator, which will give the product required.

Example.—Multiply $\frac{5}{6}$, $\frac{3}{8}$, and $2\frac{1}{2}$ together.
$\frac{5}{6} \times \frac{3}{8} \times (2\frac{1}{2}$ or$)\ \frac{5}{2} = \frac{75}{96}$. *Answer.*

DIVISION OF FRACTIONS.

Rule.—Prepare the fractions, as for multiplication; then divide the numerator by the numerator, and the denominator by the denominator, if they will exactly divide; but if they will not do so, then invert the terms of the divisor, and multiply the dividend by it, as in multiplication.

Example.—Divide $\frac{9}{16}$ by $4\frac{1}{2}$.
$\frac{9}{16} \div (4\frac{1}{2}$ or$)\ \frac{9}{2} = \frac{1}{8}$. *Answer.*

RULE OF THREE IN FRACTIONS.

Rule.—State the terms, as directed in "Simple proportion;" reduce them (if necessary) to improper, or simple fractions, and the *two first* to the same denomination. Then multiply together the second and third terms, and the first with its parts inverted, as in division, for the answer.

Example.—If $4\frac{1}{5}$ cwt. of sugar cost £$19\frac{7}{8}$, how much may be bought for £$59\frac{5}{8}$?

As $19\frac{7}{8} : 59\frac{5}{8} :: 4\frac{1}{5} :$
Or, $\frac{159}{8} : \frac{477}{8} :: \frac{21}{5} : 12\frac{3}{5}$. *Answer.*
$\frac{8}{159} \times \frac{477}{8} \times \frac{21}{5} = \frac{80136}{6360} = 12\frac{3}{5}$ cwt.

DECIMALS.

A decimal fraction is that which has for its denominator an unit (1), with as many ciphers annexed as the numerator has places; and it is usually expressed by setting down the numerator only with a point before it, on the left hand. Thus, $\frac{5}{10}$ is ·5; $\frac{25}{100}$ is ·25; $\frac{25}{1000}$ is ·025; ciphers being *prefixed,* to make up as many places as are required by the ciphers in the denominator.

A mixed number is made up of a whole number with some decimal fraction, the one being separated from the other by a point, thus 3·25 is the same as $3\frac{25}{100}$ or $\frac{325}{100}$.

Ciphers on the right hand of decimals make no alteration in their *value;* for ·5, ·50, ·500 are decimals having all the same value, each *being* $= \frac{5}{10}$. But when they are placed on the left hand, they decrease *the* value in a tenfold proportion; thus, ·5 is $\frac{5}{10}$; but, ·05 is $\frac{5}{100}$.

ADDITION OF DECIMALS.

Rule.—Set the numbers under each other, according to the value of their places, in which state the decimal separating points will all stand exactly under each other. Then beginning at the right hand, add up all the columns of numbers as in integers, and point off as many places for decimals as are in the greatest number of decimal places in any of the lines that are added; or place the point directly below all the other points.

Example.—Required the sum of 29·0146, 3146·5, 14·16, and 165.

```
          29·0146
        3146·5
          14·16
         165·
        ---------
Answer  3354·6746
```

SUBTRACTION OF DECIMALS.

Rule.—Place the numbers under each other according to the value of their places. Then, beginning at the right hand, subtract as in whole numbers, and point off the decimals, as in addition.

Example.—Subtract 4·90142 from 214·81.

```
        214·81
          4·90142
        ---------
Answer  209·90858
```

MULTIPLICATION OF DECIMALS.

Rule.—Place the factors, and multiply them together, the same as if they were whole numbers. Then point off in the product just as many places of decimals as there are decimals in both the factors. But, if there be not so many figures in the product, prefix ciphers to supply the deficiency.*

Example.—Multiply 32·108 by 2·5.

```
  32·108
     2·5
  ------
  160540
  64216
  ------
 80·2700 Answer.
```

* *To multiply decimals by 1, with any number of ciphers, as 10, 100, &c.*—This is done by only removing the decimal point so many places farther to the right hand, as there are ciphers in the multiplier, and subjoining ciphers, if need be.

DIVISION OF DECIMALS.

Rule.—Divide as in whole numbers, and point off in the quotient as many places for decimals as the decimal places in the dividend exceed those in the divisor. When the decimal places of the quotient are not so many as the above rule requires, the deficiency is to be supplied by prefixing ciphers. When there is a remainder after the division, or when the decimal places in the divisor are more than those in the dividend, then ciphers may be annexed to the dividend, and the quotient carried on as far as required.

Example.—Divide 234·7052 by 64·25.

```
64·25)234·7052(3·65 Answer.
      19275
      -----
       41955
       38550
       -----
        34052
        32125
        -----
         1927 Remainder.
```

REDUCTION OF DECIMALS.

To reduce a vulgar fraction to its equivalent decimal.

Rule.—Divide the numerator by the denominator, as in Division of Decimals, annexing ciphers to the numerator as far as necessary: and the quotient will be the decimal required.

Example.—Reduce $\frac{7}{24}$ to a decimal.

```
24 = 4 × 6.  Then 4)7·
                  ------
                 6)1·75
                  ------
                   ·291666, &c., Answer.
```

To find the value of a decimal, in terms of the inferior denominations.

Rule.—Multiply the decimal by the number of parts in the next lower denomination, and cut off as many places to the right hand for a remainder, as there are places in the given decimal. Multiply that remainder by the parts in the next lower denomination, again cutting off for another remainder as before. Proceed in the same manner through all the parts of the integer; then the several denominations, separated on the left hand, will make up the answer.

Example.—What is the value of ·775 pounds sterling?

$$\begin{array}{rr} & \cdot 775 \\ & 20 \\ \hline \text{Shillings} & 15\cdot 500 \\ & 12 \\ \hline \text{Pence} & 6\cdot 000 \end{array}$$

Answer 15*s.* 6*d.*

To convert integers, or decimals, to equivalent decimals of higher denominations.

Rule.—Divide by the number of parts in the next higher denomination, continuing the operation to as many higher denominations as may be necessary.

When there are several numbers, all to be converted to the decimal of the highest—

Set the given numbers directly under each other for dividends, proceeding from the lowest to the highest; opposite to each dividend, on the left hand, place such a number for a divisor as will bring it to the next higher name. Begin at the uppermost, and perform all the divisions, placing the quotient of each division, as decimal parts, on the right hand of the dividend next below it; so shall the last quotient be the decimal required.

Example.—Convert 15*s.* $9\frac{3}{4}$*d.* to the decimal of a pound sterling.

$$\begin{array}{r|l} 4 & 3\cdot \\ 12 & 9\cdot 75 \\ 20 & 15\cdot 8125 \\ \end{array}$$

£·790625 *Answer.*

Example.—Convert 1 dwt. to the decimal of a pound, Troy weight.

$$\begin{array}{l} 20)1 \\ \hline 12)\cdot 05 \text{ oz.} \\ \hline \cdot 004166 \text{ lb., \&c.,} \end{array}$$

Answer.

RULE OF THREE IN DECIMALS.

Rule.—Prepare the terms, by reducing the fractions to decimals; compound numbers to decimals of the higher denominations, or integers of the lower; also the first, and second terms to the same name. Then multiply, and divide, as in the Rule of Three, in whole *numbers.*

Example.—If $\frac{3}{8}$ of a yard of cloth cost £$\frac{2}{5}$, what will $\frac{5}{16}$ of a yard cost?

$\frac{3}{8} = \cdot375$

$\frac{2}{5} = \cdot4$

$\frac{5}{16} = \cdot3215$

Answer, 6*s*. 8*d*.

$$\begin{array}{llllll} & \text{yd.} & \text{yd.} & \text{£.} & & \text{s. d.} \\ \text{As } \cdot375 : & \cdot3125 :: & \cdot4 : & \cdot333 \text{ \&c, or } & & 6\ 8 \end{array}$$

$$\begin{array}{rl} & 4 \\ \hline \cdot375)\cdot12500 & (\cdot3333 \text{ \&c.} \\ 1125 & \quad 20 \\ \hline 1250 & s.\ 6\cdot666 \text{ \&c.} \\ 1125 & \quad 12 \\ \hline 125 & d.\ 7\cdot\dot{9}99 \text{ \&c. nearly } 8d. \end{array}$$

DUODECIMALS.

By Duodecimals, artificers, &c., compute the content of their works.

Rule.—Set down the two dimensions to be multiplied together one under the other, so that feet may stand under feet, inches under inches, &c.

Multiply each term in the multiplicand, beginning at the lowest, by the feet in the multiplier, and set the result of each straight under its corresponding term, observing to carry 1 for every 12, from the inches to the feet. In like manner multiply all the multiplicand by the inches, and parts of the multiplier, and set the result of each term one place removed to the right hand of those in the multiplicand: omitting, however, what is below parts of inches, only carrying to these the proper number of units from the lowest denominations. Or, instead of multiplying by the inches, take such part of the multiplicand as those are of a foot.

Then add the two lines together for the content required.

Example.—Multiply 14 feet 9 inches, by 4 feet 6 inches.

$$\begin{array}{rl} \text{ft.} & \text{in.} \\ 14 & 9 \\ 4 & 6 \\ \hline 59 & 0 \\ 7 & 4\frac{1}{2} \\ \hline 66 & 4\frac{1}{2} \text{ } \textit{Answer.} \\ \hline \end{array}$$

INVOLUTION.

Involution is the raising of powers from any given number, as a root.

A Power is a quantity produced by multiplying any given number, called the *Root*, a certain number of times continually by itself.

Thus, $2 \times 2 = 4$, the 2nd power, or square of 2, expressed thus, 2^2.

The index, or exponent of a power is the number denoting the height, or degree of that power.

Thus, 2 is the index of the 2nd power.

Powers that are to be raised, are usually denoted by placing the index above the root, or first power.

Thus, $2^2 = 4$, the second power of 2.

Example.—What is the 2nd power of 45?

$45 \times 45 = 2025$ *Answer.*

EVOLUTION.

Evolution is the reverse of Involution, being the extracting, or finding the roots of any given powers, or numbers.

The Root of any number, or power, is such a number as being multiplied into itself a certain number of times, will produce that power.

Thus, 2 is the square root, or second root of 4, because, $2^2 = 2 \times 2 = 4$; and 3 is the cube root, or third root of 27. But there are many numbers of which a proposed root can never be exactly found; by means of decimals, however, the root may be very nearly ascertained.

Any power of a given number, or root, may be found exactly by multiplying the number continually into itself.

Those roots which only approximate are called *Surd roots;* but those which can be found, quite exactly, are called *Rational roots.* Thus, the square root of 3 is a surd root, but the square root of 4 is a rational root, being equal to 2; also the cube root of 8 is rational, being equal to 2, but the cube root of 9 is surd, or irrational. Roots are sometimes denoted by writing the character $\sqrt{}$ before the power with the index of the root against it. Thus, the 3rd, or cube root of 20 is expressed by $\sqrt[3]{20}$. When the power is expressed by several numbers with the sign + or − between them, a line is drawn from the top of the sign over all the parts of it; thus the cube (or third) root of $45 - 12$ is $\sqrt[3]{45 - 12}$ or thus $\sqrt[3]{(45 - 12)}$.

TO EXTRACT THE SQUARE ROOT.

Rule.—Divide the given number into periods of two figures each, by setting a point over the place of units, and another over the place of hundreds, and so on over every second figure, both to the left hand in integers, and right hand in decimals. Find the greatest square in the first period on the left hand, and set its root on the right hand of the given number, after the manner of the quotient figure in division. Subtract the square thus found from the said period, and to the remainder annex the two figures of the next following period for a

dividend. Double* the root above mentioned for a divisor, and find how often it is contained in the said dividend, exclusive of its right-hand figure; and set that quotient figure both in the quotient and divisor. Multiply the whole augmented divisor by this last quotient figure, and subtract the product from the said dividend, bringing down to it the next period of the given number, for a new dividend. Repeat the same process over again—viz., find another new divisor, by doubling all the figures now found in the root; from which, and the last dividend find the next figure of the root as before; and so on through all the periods to the last.

To extract the square root of a fraction, or mixed number.

Reduce the fraction to a decimal, and extract its root.

Mixed numbers may be either reduced to improper fractions, and the root extracted; or the fraction may be reduced to a decimal, then joined to the integer, and the root of the whole extracted.

Example.—To find the square root of 29506624; and 17·3056.

```
       . . . .                           .  . .
       29506624 (5432 The Root.        17·3056 (4·16 The Root.
       25                              16
       ----                            ----
104  | 450                        81 | 130
  4  | 416                         1 |  81
-----------                      ----------
1083 | 3466                      826 | 4956
   3 | 3249                        6 | 4956
-----------
10862 | 21724
    2 | 21724
```

TO EXTRACT THE CUBE ROOT.

Rule 1.—By trials, or by the table of roots (*vide page* 334), take the nearest rational cube to the given number, whether it be greater, or less, and call it the assumed cube.

2.—Then (*by the Rule of Three*),

As the sum of the given number, and double the assumed cube, is to the sum of the assumed cube, and double the given number, so is the root of the assumed cube, to the root required, nearly.

3.—Or, as the first sum,

is to the difference of the given, and assumed cube,
so is the assumed root,
to the difference of the roots, nearly.

---

* The best way of doubling the root to form the new divisor, is by adding the last figure always to the last divisor, as appears in the following example.

After the figures belonging to the given number are all exhausted, the operation may be continued into decimals, by adding any number of periods of ciphers, two in each period.

4.—Again, by using, in like manner, the cube of the root last found as a new assumed cube, another root will be obtained still nearer. Repeat this operation as often as necessary, using always the cube of the last-found root, for the assumed root.

Example.—To find the cube root of 21035·8.

By trials it will be found *first*, that the root lies between 20, and 30; and, *secondly*, between 27, and 28. Taking, therefore, 27, its cube is 19683, which will be the assumed cube. Then by No. 2 of the Rule,

19683	21035·8
2	2
39366	42071·6
21035·8	19683·

As 60401·8 : 61754·6 : : 27 : 27·6047 the Root, nearly.

Again, for a second operation, the cube of this root is 21035·318645155832, and the process by No. 3 of the Rule will be

21035·318645, &c.	
2	
42070·637290	21035·8
21035·8	21035·318645, &c.

As 63106·43729 : diff. ·481355 : : 27·6047 :
: the diff. ·000210560

consequently the root required is 27·604910560

TABLE OF SQUARES, CUBES, AND ROOTS.

No.	Sqr.	Cube.	Sqr. root.	Cube root.	No.	Sqr.	Cube.	Sqr. root.	Cube root.
1	1	1	1·0000000	1·000000	51	2601	132651	7·1414284	3·708430
2	4	8	1·4142136	1·259921	52	2704	140608	7·2111026	3·732511
3	9	27	1·7320508	1·442250	53	2809	148877	7·2801099	3·756286
4	16	64	2·0000000	1·587401	54	2916	157464	7·3484692	3·779763
5	25	125	2·2360680	1·709976	55	3025	166375	7·4161985	3·802953
6	36	216	2·4494897	1·817121	56	3136	175616	7·4833148	3·825862
7	49	343	2·6457513	1·912933	57	3249	185193	7·5498344	3·848501
8	64	512	2·8284271	2·000000	58	3364	195112	7·6157731	3·870877
9	81	729	3·0000000	2·080084	59	3481	205379	7·6811457	3·892996
10	100	1000	3·1622777	2·154435	60	3600	216000	7·7459667	3·914867
11	121	1331	3·3166248	2·223980	61	3721	226981	7·8102497	3·936497
12	144	1728	3·4641016	2·289428	62	3844	238328	7·8740079	3·957892
13	169	2197	3·6055513	2·351335	63	3969	250047	7·9372539	3·979057
14	196	2744	3·7416574	2·410142	64	4096	262144	8·0000000	4·000000
15	225	3375	3·8729833	2·466212	65	4225	274625	8·0622577	4·020726
16	256	4096	4·0000000	2·519842	66	4356	287496	8·1240384	4·041240
17	289	4913	4·1231056	2·571282	67	4489	300763	8·1853528	4·061548
18	324	5832	4·2426407	2·620741	68	4624	314432	8·2462113	4·081656
19	361	6859	4·3588989	2·668402	69	4761	328509	8·3066239	4·101566
20	400	8000	4·4721360	2·714418	70	4900	343000	8·3666003	4·121285
21	441	9261	4·5825757	2·758923	71	5041	357911	8·4261498	4·140818
22	484	10648	4·6904158	2·802039	72	5184	373248	8·4852814	4·160168
23	529	12167	4·7958315	2·843867	73	5329	389017	8·5440037	4·179339
24	576	13824	4·8989795	2·884499	74	5476	405224	8·6023253	4·198336
25	625	15625	5·0000000	2·924018	75	5625	421875	8·6602540	4·217163
26	676	17576	5·0990195	2·962496	76	5776	438976	8·7177979	4·235824
27	729	19683	5·1961524	3·000000	77	5929	456533	8·7749644	4·254321
28	784	21952	5·2915026	3·036589	78	6084	474552	8·8317609	4·272659
29	841	24389	5·3851648	3·072317	79	6241	493039	8·8881944	4·290841
30	900	27000	5·4772256	3·107232	80	6400	512000	8·9442719	4·308870
31	961	29791	5·5677644	3·141381	81	6561	531441	9·0000000	4·326749
32	1024	32768	5·6568542	3·174802	82	6724	551368	9·0553851	4·344481
33	1089	35937	5·7445626	3·207534	83	6889	571787	9·1104336	4·362071
34	1156	39304	5·8309519	3·239612	84	7056	592704	9·1651514	4·379519
35	1225	42875	5·9160798	3·271066	85	7225	614125	9·2195445	4·396830
36	1296	46656	6·0000000	3·301927	86	7396	636056	9·2736185	4·414005
37	1369	50653	6·0827625	3·332222	87	7569	658503	9·3273791	4·431047
38	1444	54872	6·1644140	3·361975	88	7744	681472	9·3808315	4·447960
39	1521	59319	6·2449980	3·391211	89	7921	704969	9·4339811	4·464745
40	1600	64000	6·3245553	3·419952	90	8100	729000	9·4868330	4·481405
41	1681	68921	6·4031242	3·448217	91	8281	753571	9·5393920	4·497942
42	1764	74088	6·4807407	3·476027	92	8464	778688	9·5916630	4·514357
43	1849	79507	6·5574385	3·503398	93	8649	804357	9·6436508	4·530655
44	1936	85184	6·6332496	3·530348	94	8836	830584	9·6953597	4·546836
45	2025	91125	6·7082039	3·556893	95	9025	857375	9·7467943	4·562903
46	2116	97336	6·7823300	3·583048	96	9216	884736	9·7979590	4·578857
47	2209	103823	6·8556546	3·608826	97	9409	912673	9·8488578	4·594701
48	2304	110592	6·9282032	3·634241	98	9604	941192	9·8994949	4·610436
49	2401	117649	7·0000000	3·659306	99	9801	970299	9·9498744	4·626065
50	2500	125000	7·0710678	3·684031	100	10000	1000000	10·0000000	4·641589

PILING OF SHOT, AND SHELL.

Shot, and shells, are usually piled in horizontal courses, the base being either an equilateral triangle, a square, or a rectangle. The triangular, and square piles terminate each in a single ball, but the rectangular pile finishes in a row of balls.

To find the number of balls in a complete pile.

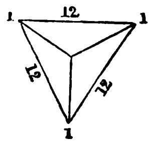
Rule.—Add the three parallel edges together ; then the product of one-third of that sum, and of the number of balls in the triangular face, will be the number sought.

Note 1.—*The parallel edges* in a *rectangular pile* are the two rows in length at the base, and the upper ridge. In the *square pile* the same, except that the upper row is only a single ball. In the *triangular pile*, one side of the base, the single ball at top, and that at the back, are considered the parallel edges.

Note 2.—*The number of balls in the triangular face* is found by multiplying half the number in the breadth at the base, by the number in the breadth at the base *plus* 1.

Note 3.—In all piles, the breadth of the bottom is equal to the number of courses. In the oblong pile the top row is one more than the difference between the length, and breadth of the bottom.

Example.—To find the shot in a Triangular pile, the bottom row consisting of 12 shot.



Parallel edges $\begin{cases}12\\1\\1\end{cases}$

3)14

$4\frac{2}{3}$

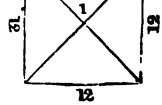
$12 \div 2 = 6$
$12+1=13$

Triangular face 78
$4\frac{2}{3}$

312
52

Answer 364

Example.—To find the shot in a Square pile, the bottom row consisting of 12 shot.



12
12
1

3)25

$8\frac{1}{3}$

$12 \div 2 = 6$
$12+1=13$

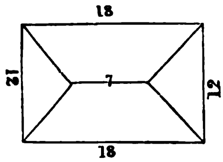
78
$8\frac{1}{3}$

624
26

Answer 650

Example.—To find the shot in an Oblong pile, whose base consists of 18 shot in length, and 12 in breadth.

$18-12=6$	18	$12 \div 2 = 6$
1	18	$12+1=13$
7	7	78
	3)43	$14\frac{1}{3}$
	$14\frac{1}{3}$	312
		78
		26
	Answer	1118



The number of balls in a Pile may be found by using the following formulæ, in which let the letter (L) denote the number in the bottom row, or the Length; and (B) the Breadth of the lowest course.

Triangular pile $\frac{L \times (L+1) \times (L+2)}{6}$

Square pile $\frac{L \times (L+1) \times (2L+1)}{6}$

Oblong pile $\frac{B \times (B+1) \times (3L+1-B)}{6}$

By referring to the following Table, the number of Shot in any Pile (whose base does not exceed 21) may readily be ascertained.

Square pile.—Look for the number of shot in the base, in the first vertical column on the left hand, and also in the diagonal column; and at their angle of meeting will be found the content required.

Thus, 20 base gives 2870.

Triangular pile.—Look for the number in the base row in the diagonal column, and opposite to it will be found the content.

Thus, 18 base gives 1140.

Oblong pile.—Look for the number in the length of the base in the vertical column, and the breadth of the base in the diagonal column, and at their angle of meeting will be found the content required.

Thus, 17 length, and 12 breadth, gives 1040.

To find the number of balls in an Incomplete pile.—Compute the number in the pile considered as complete; also the number in the upper pile, or part wanting; and the difference between the two piles thus found will be the number in the frustum, or incomplete pile.

Table for computing the Content of any Pile, whose base row does not exceed 21 balls.

1	2	4																				
2	5	3	10																			
3	8	14	4	20																		
4	11	20	30	5	35																	
5	14	26	40	55	6	56																
6	17	32	50	70	91	7	84															
7	20	38	60	85	112	140	8	120														
8	23	44	70	100	133	168	204	9	165													
9	26	50	80	115	154	196	240	285	10	220												
10	29	56	90	130	175	224	276	330	385	11	286											
11	32	62	100	145	196	252	312	375	440	506	12	364										
12	35	68	110	160	217	280	348	420	495	572	650	13	455									
13	38	74	120	175	238	308	384	465	550	638	728	819	14	56								
14	41	80	130	190	259	336	420	510	605	704	806	910	1015	15	680							
15	44	86	140	205	280	364	456	555	660	770	884	1001	1120	1240	16	816						
16	47	92	150	220	301	392	492	600	715	836	962	1092	1225	1360	1496	17	969					
17	50	98	160	235	322	420	528	645	770	902	1040	1183	1330	1480	1632	1785	18	1140				
18	53	104	170	250	343	448	564	690	825	968	1118	1274	1435	1600	1768	1938	2109	19	1330			
19	56	110	180	265	364	476	600	735	880	1034	1196	1365	1540	1720	1904	2091	2280	2470	20	1540		
20	59	116	190	280	385	504	636	780	935	1100	1274	1456	1645	1840	2040	2244	2451	2660	2870	21	1771	
21	62	122	200	295	406	532	672	825	990	1166	1352	1547	1750	1960	2176	2397	2622	2850	3080	3311	22	2024

Z

CORDAGE.

Ropes, cables, and all other descriptions of cordage are distinguished by their circumference; thus a two-inch rope means a rope two inches in circumference.

1. *To find the weight of a rope.*

First method.—Multiply the length in fathoms by the square of the circumference, and divide the product by 480 for the weight in cwts.

Example.—Required the weight of 110 fathoms of 3-inch rope.

$3 \times 3 \times 110 = 990$, which divided by 480, gives 2 cwt. 7 lb. Weight required.

Second method.—Divide the square of the circumference by 4, the quotient will give the weight, in pounds, per fathom.

Example.—What is the weight of a 3-inch rope per fathom?

$3^2 \div 4 = 2\frac{1}{4}$ lb. Weight required.

2. *To find the strength of a rope, or the weight it will support.*

First method.—Square the circumference, and divide by 5, for the number of tons which it will bear suspended from it.*

Example.—What weight will 3-inch rope of the best description support?

$$\frac{3 \times 3}{5} = \frac{9}{5} = 1\frac{4}{5} \text{ ton, or 4030 lb.}$$ Weight required.

Second method.—Multiply the square of the circumference by 2, the product will give the *practical weight in cwts.* that may be lifted by it, or about half the breaking weight.

Example.—What number of cwts. may be lifted by a 3-inch rope?

$3^2 \times 2 = 18$ cwt. Weight required.

$$\left.\begin{array}{l}\textit{The strain}, \text{ in pounds, } \textit{a rope will bear safely} = \text{girt}^2 \times 200 \\ \quad ,, \qquad\qquad ,, \quad \textit{a cable} \qquad ,, \qquad ,, \quad = \text{girt}^2 \times 120\end{array}\right\} \text{nearly.}$$

CHAINS.

1. *To find the weight of chains.*

The square of the diameter of the link, measured in eighths of inches, will give the weight of the chain, per fathom, in pounds.

Example.—What is the weight per fathom of a $\frac{3}{4}$-inch chain?

$\frac{3}{4}$-inch $= \frac{6}{8}$; $6^2 = 36$ lb. Weight per fathom.

Or, the weights per foot of the chain, multiplied by 24, will give the weight per fathom of the chain, *nearly.* A chain cable with a stay across the links will weigh about one-twelfth more than the foregoing examples.

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* *This rule is only applicable to the very best made new cordage. The circumference squared should be divided by 6 instead of 5 for the description of rope generally employed.*

2. *To find the weight that may be safely lifted by a chain.*

Divide the square of the diameter of the links, taken in eighths of an inch by 8, and the quotient will give the number of tons that may be lifted by the chain.

Example.—What number of tons will a chain made of $\frac{3}{4}$-inch iron carry with safety?

$\frac{3}{4}$-inch $= \frac{6}{8}$ $\quad 6^2 = 36 \quad \frac{36}{8} = 4\frac{1}{2}$ tons. Weight required.

The safe strain is equal to about 8 tons, per square inch, of the iron of which the chain is made.

The stay across the link of a chain increases its strength about one-sixth.

When the chain is of great length, a deduction, from the above rules, must be allowed for the weight of it.

IRON RODS.

1. *To find the weight of round iron rods.*

Divide the square of the diameter, in quarter inches, by 2, and the quotient will give the weight in pounds, per yard.

Example.—What is the weight of a yard of 1-inch round iron?

1 inch $= 4$ quarters $\quad 4^2 = 16 \quad \frac{16}{2} = 8$ lb. Weight required.

2. *To find the weight of square rods.*

The weight of round rods, of similar diameter, divided by ·7854 will give the weight of the square rods.

3. *To find the weight that may be sustained, or lifted by round iron rods.*

Find the weight in pounds, per yard; two-thirds of which will give the safe load, in tons.

A round iron rod of average quality of iron, one inch in diameter, will be torn asunder by 16 tons; it will be perceptibly damaged by half this strain, or 8 tons; its safe load will be one-third, or 5·33 tons.

4. *To reduce cubic feet of wrought iron into tons.*

The cubic feet multiplied by 1·5, divided by 7 = Tons.

One foot of 1-inch square wrought iron weighs 3·33 lb.

„ „ round „ „ 2·61 lb.

GIRDERS, weight of.

Wrought iron, weighing 480 pounds per cubic foot.

The sectional area, in inches, multiplied by the length in feet divided by 672 = weight in tons.

The sectional area in inches multiplied by 10 = weight of bar, in pounds, per yard.

For cast iron, deduct one twentieth.

TIMBER.

1. *To find the area, or superficial content of a plank.*

Multiply the length by the mean breadth.*

Example.—Required the content of a board whose length is 11 feet 2 inches, and breadth 1 foot 10 inches.

ft. in.		ft. in.		ft. in.	
11 2	×	1 10	=	20 5.	Content required.

2. *To find the solid content of squared, or four-sided timber.*

Multiply the mean breadth by the mean thickness, and the product by the length, for the content, nearly.

Note 1.—If the tree taper regularly from the one end to the other, either take the mean breadth, and thickness in the middle, or take the dimensions at the two ends, and half their sum will be the mean dimensions; which, multiplied by the above rule, will give the content, nearly.

Note 2.—If the piece do not taper regularly, take several different dimensions, add them all together, and divide their sum by the number of them, for the mean dimensions.

Example.—Required the content of a piece of timber 16 feet long, and side of square 14 inches.

ft. in.		ft. in.		ft.		ft. in.	
1 2	×	1 2	×	16	=	21 9.	Content required.

3. *To find the solidity of round, or unsquared timber.*

1. Multiply the square of the quarter girt (or the square of $\frac{1}{4}$ of the mean circumference), by the length, for the content.

Note.—When the tree is tapering, take the mean dimensions, either by girting it in the middle for the mean girt, or at the two ends, taking half the sum of the two; or by girting it in several places, then adding all the girts together, and dividing the sum by the number of them for the mean girt But when the tree is very irregular, divide it into several lengths, and find the content of each part separately.

Example.— Required the content of a tree, whose mean girt is 3·15 feet, and length $14\frac{1}{2}$ feet.

$$\frac{3\cdot15}{4} = \cdot7875 \quad \cdot7875 \times \cdot7875 = \cdot62015625 \quad 14\tfrac{1}{2} = 14\cdot5.$$

$\cdot62015 \times 14\cdot5 = 8\cdot9922$ feet of solid timber. The content required.

2. Find the mean area of a round tree, and multiply it by the length for the content.

4. *To find the weight of a tree.*

Find its content in feet, and multiply that by the specific gravity of the wood.

(*Vide* GRAVITY, *and Table of Specific Gravities. P.* 353.)

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* When the board is tapering, add the breadths at the two ends together, and take half the sum for the mean breadth. Or else, take the mean breadth in the middle.

Example.—Required the weight of an elm tree, whose mean girt is 5 feet, and length 60 feet.

$\frac{5}{4} = 1{\cdot}25 \qquad 1{\cdot}25 \times 1{\cdot}25 = 1{\cdot}5625.$

$1{\cdot}5625 \times 60 = 93{\cdot}75.$ Content in feet.

TONNAGE.

Table of Tonnage, and Weight of *One* of the following Carriages, Carts, Waggons, Gyns, &c., used in Land service.

	Tonnage.		Weight.			
	tons.	ft.	cwt.	qrs.	lb.	
Carriages. Travelling, complete. For Iron Ordnance. 24 pounder	6	0	34	0	22	With bullock pole and chain, weighing 2 qr. 19 lb.
8 inch	6	0	34	2	12	
18 pounder	4	39	27	2	9	
12 „ 21 cwt.	4	7	18	3	24	
Howitzer 10 inch	6	17	39	0	9	
Howitzer 8 „	5	37	33	2	0	Do. do. do.
For Brass Ordnance. 12 pounder	5	33	22	0	10	
9 „	5	1	20	2	14	
6 „	4	21	17	3	5	
Howitzer 32 pr.	5	29	23	3	13	
Howitzer 24 „	5	6	21	0	17	
Howitzer 12 „	4	21	18	3	14	
Ammunition waggon	5	36	20	0	3	For all natures.
Forge	5	38	19	1	0	
Store waggon (without spare wheel)	5	11	18	1	10	
Small arm ammunition waggon	4	36	14	2	16	
Rocket 12 pounder	7	33	20	2	8	
Rocket 6 „	5	17	20	1	20	
Pontoon Large	3	30	42	2	13	
Pontoon Small	..		22	2	5	
Garrison, wood, common standing, for 32 pounder of 25 cwt.	1	8	8	0	7	
Capstan, crab		31	3	3	26	
Carts. Forge, cavalry	4	32	11	2	3	
Hand	1	10	4	3	4	
Hospital, conveyance	3	16	10	2	20	
Sling	3	38	16	1	17	
Store	3	16	9	1	0	
Trench	1	32	5	2	13	
Drugs Large	2	7	17	1	24	
Drugs Small		29	5	0	4	
Gyns, Triangle Large	1	23	9	2	22	
Gyns, Triangle Small	1	2	7	3	3	
Platform Madras For 32 pounder garrison carriage		26	6	0	12	Fir.
Platform Madras For traversing carriage with tail-piece	1	23	14	2	0	Teak.
Platform Mortar, Alderson's pattern		30	8	1	4	
Portable forge, and pack saddle, in wooden case		17	2	1	3	
Waggons Flanders	5	0	16	1	25	
Waggons Platform	3	16	21	3	18	
Waggons Sling	8	11	31	3	26	
Waggons, hospital, Mr. Holmes' *pattern* Large	9	10	21	0	0	
Waggons, hospital, Mr. Holmes' *pattern* Small	6	30	18	0	4	

The calculation of tonnage for baggage, stores, &c., is by measurement: *a Ton*, consisting of 40 cubic feet; but metals, and very heavy articles are estimated by actual weight, without reference to bulk.

To ascertain the tonnage of sailing Vessels, the hold being clear.

Rule.—Divide the length of the upper deck, between the afterpart of the stem, and the forepart of the sternpost, into six equal parts.

Depths.—At the foremost, the middle, and the aftermost of those points of division, measure in feet, and decimal parts of a foot, the depth from the under side of the upper deck to the ceiling at the limber strake. In the case of a break in the upper deck, the depths are to be measured from a line stretched in a continuation of the deck.

Breadths.—Divide each of those three depths into five equal parts, and measure the inside breadths at the following points—viz., at one-fifth, and at four-fifths from the upper deck of the foremost, and aftermost depths, and at two-fifths, and four-fifths from the upper deck of the midship depth.

Length.—At half the midship depth, measure the length of the vessel from the afterpart of the stem to the forepart of the sternpost; then to twice the midship depth add the foremost, and the aftermost depths for the sum of the depths; add together the upper, and lower breadths at the foremost division, three times the upper breadth, and the lower breadth at the midship division, and the upper, and twice the lower breadth at the after division, for the sum of the breadths: then multiply the sum of the depths by the sum of the breadths, and this product by the length, and divide the final product by 3500, which will give the number of tons for register.

If the vessel have a poop, or half deck, or a break in the upper deck, measure the inside mean length, breadth, and height of such part thereof as may be included within the bulk-head; multiply these three measurements together, and dividing the product by 92·4, the quotient will be the number of tons to be added to the result as above found.

In order to ascertain the tonnage of open vessels, the depths are to be measured from the upper edge of the upper strake.

To ascertain the tonnage of Steam-vessels.

Rule.—In addition to the foregoing rules, when applied for the purpose of ascertaining the tonnage of any ship or vessel propelled by steam, the tonnage due to the cubical content of the engine-room must be deducted from the total tonnage of the vessel, as determined by either of the rules aforesaid, and the remainder will be the true register tonnage of the said ship or vessel.

To determine the tonnage due to the cubical content of the Engine-room.

Rule.—Measure the inside length of the engine-room in feet and decimal parts of a foot, from the foremost to the aftermost bulkhead, then multiply the said length by the depth of the ship or vessel at the midship division as aforesaid, and the product by the inside breadth of the same division at two-fifths of the depth from the

deck, taken aforesaid, and divide the last product by 92·4, and the quotient will be the tonnage due to the cubical content of the engine-room.

To ascertain the tonnage of Vessels when laden.

Rule.—Measure, *first*, the length on the upper deck between the afterpart of the stem, and the fore-part of the stern-post; *secondly*, the inside breadth on the under side of the upper deck, at the middle point of the length; and, *thirdly*, the depth from the under side of the upper deck down the pump-well to the sink; multiply these three dimensions together, and divide the product by 130, and the quotient will be the amount of the register tonnage of such ships.

MECHANICS.

Mechanics is the science of forces, and the effects they produce when applied to machines in the motion of bodies.

Machine, or engine, is any mechanical instrument contrived to move bodies.

Equilibrium is an equality of action, or force, between two or more powers, or weights, acting against each other, by which they destroy each other's effects, and remain at rest.

The centre of motion is the fixed point about which a body moves.

The axis of motion is the fixed line about which it moves.

The centre of gravity is a certain point on which a body (being freely suspended) will rest in any position.

The whole momentum, or quantity of force of a moving body, is the result of the quantity of matter multiplied by the velocity with which it is moved.

THE MECHANICAL POWERS.

Power is compounded of the weight, or expansive force of a moving body, multiplied into its velocity.

The power of a body, which weighs 40 lb., and moves with the velocity of 50 feet in a second, is the same as that of another body which weighs 80 lb., and moves with the velocity of 25 feet in a second: for the products of the respective weights, and velocities are the same.

$$40 \times 50 = 2000\text{ ; and } 80 \times 25 = 2000.$$

Power cannot be increased by mechanical means.

Power is applied to mechanical purposes—

1. By the lever;	4. By the inclined plane;
2. By the wheel, and axle;	5. By the wedge;
3. By the pulley;	6. By the screw:

which are the simple elements of all machines.

The whole theory of these elements consists simply in causing the weight, which is to be raised, to pass through a greater or a less space than the power which raises it; for, as power is compounded of the weight or mass of a moving body, multiplied into its velocity, a *weight passing through a certain space may be made to raise, through a less space, a weight heavier than itself.*

THE LEVER.

The lever is the most simple of all machines, being only a straight bar of iron, wood, &c., supported on, and moveable round a prop, called the *fulcrum.*

Case 1.—When the fulcrum of the lever is between the power, and the weight.

Rule.—Divide the weight to be raised by the power to be applied; the quotient will give the difference of leverage necessary to support the weight in equilibrium. Hence a small addition either of leverage, or weight, will cause the power to preponderate.

Example 1.—A ball weighing 3 tons is to be raised by 4 men, who can exert a force of 12 cwt.: required the proportionate length of lever?

$$3 \text{ tons} = 60 \text{ cwt.}; \text{ and } \tfrac{60}{12} = 5.$$

In this example, the proportionate lengths of the lever to maintain the weight in equilibrium, are as 5 to 1. If, therefore, an additional pound be added to the power, the power side of the lever will preponderate, and the weight will be raised. But, although the ball is raised by a force of only one-fifth of its weight, no power is gained, for the weight passes through only one-fifth of the space. The products, therefore, arising from the multiplication of the respective weights, and velocities are the same.

Example 2.—A weight of 1 ton is to be raised with a lever 8 feet in length, by a man who can exert, for a short time, a force of rather more than 4 cwt.; required at what part of the lever the fulcrum must be placed?

$\dfrac{20 \text{ cwt.}}{4 \text{ cwt.}} = 5$; that is, the weight is to the power as 5 to 1, therefore, $\dfrac{8}{5 \times 1} = 1$ foot and a third, from the weight. Distance required.

Example 3.—A weight of 40 lb. is placed 1 foot from the fulcrum of a lever; required the power to raise the same, when the length of the lever on the other side of the fulcrum is 5 feet?

$$\frac{40 \times 1}{5} = 8 \text{ lb. } Ans.$$

Case 2.—*When the fulcrum is at one extremity of the lever, and the power at the other.*

Rule.—As the distance between the power, and the fulcrum is to the distance between the weight, and the fulcrum, so is the effect to the power.

Example 1.—Required the power necessary to raise 120 lb., when the weight is placed 6 feet from the power, and 2 feet from the fulcrum?

$$\text{As } 8 : 2 :: 120 : 30 \text{ lb. } Ans.$$

Example 2.—A beam, 20 feet in length, and supported at both

ends, bears a weight of 2 tons at the distance of eight feet from one end; required the weight on each support?

$\frac{40 \text{ cwt.} \times 8 \text{ feet}}{20 \text{ feet}} = 16$ cwt. on the support that is furthest from the weight; and $\frac{40 \times 12}{20 \text{ feet}} = 24$ cwt. on the support nearest to the weight.

Case 3.—*When the weight to be raised is at one end of the lever, the fulcrum at the other, and the power is applied between them.*

Rule.—As the distance between the power, and the fulcrum, is to the length of the lever, so is the weight, to the power.

Example.—The length of the lever being 8 feet, and the weight at its extremity 60 lb., required the power to be applied 6 feet from the fulcrum to raise it?

As 6 : 8 : : 60 : 80 lb. *Ans.*

Velocity is gained at the expense of power by the lever, and wheel and axle.

Note 1.—When two men are carrying a load on a pole between them, the strongest man should have the weight placed nearer to him than the other man.

Note 2.—*To carry guns, &c.*—If the burden can be carried by four men; after having made it fast to the middle of a large lever, fix the extremities of this lever on two shorter levers, and place a man at each of the points, C, D, E, F. *Vide plate, Mechanics, Fig.* 1. In *Fig* 2, the weight is equally divided between eight men, and in *Fig.* 3, between sixteen men.

THE WHEEL, AND AXLE.

The advantage gained is in proportion as the circumference of the wheel exceeds that of the axle; therefore, the larger the wheel, and the smaller the axle, the stronger is the power of this machine, but then the weight will rise proportionately slower. A winch may be used instead of a wheel, for in turning the winch the hand will describe a circle, and there is no difference in the result, whether an entire wheel be turned, or a single spoke which the winch as a lever represents.

Rule.—As the radius of the wheel is to the radius of the axle, so is the effect, to the power.

Example.—A weight of 50 lb. is exerted on the periphery of a wheel, whose radius is 10 feet; required the weight raised at the extremity of a cord wound round the axle, the radius being 20 inches.

$$\frac{50 \text{ lb.} \times 10 \text{ feet} \times 12 \text{ inches}}{20 \text{ inches}} = 300 \text{ lb. } \textit{Ans.}$$

THE PULLEY.

The pulley consists of a grooved wheel, called *a sheave*, moveable on an axis, or gudgeon, and enclosed in a frame, or case, called a *block*. By passing a cord over the pulley, a man will be enabled *to draw up* a weight equal to that which his own body supplies in pulling downwards.

By combining a number of pulleys, as many assistants are obtained

as there are wheels: thus, two pulleys will have double the power of one, because half the weight is sustained by the frame to which one end of the cord is attached; but then it requires ***double the time*** to do the work. As the *friction of the pulley* is very great, particular attention must be paid that all the turns or kinks of a rope be taken out, before it is made use of, and it should enter easily into the grooves of the s .eaves.

Rule.—Divide the weight to be raised by twice the number of pulleys in the lower block; the quotient will give the power necessary to raise the weight.

Example.—What power is required to raise 600 lb., when the lower block contains six pulleys?

$$\frac{600}{6 \times 2} = 50 \text{ lb. } \textit{Ans.}$$

COMBINATION OF PULLEYS.

A leading block is a fixed pulley, which alters the direction of the power, but does not increase it: Power = Weight. On account of friction the power must exceed the weight a little, in order to raise it.

Vide plate, Mechanics, Fig. 1.

A whip is one moveable pulley, which increases the power without altering the direction.

Power = $\frac{1}{2}$ weight (or 2 to 1).—*Vide Fig.* 2.

A whip upon whip will afford the same purchase as a tackle having a single and double block, and with much less friction.

A gun tackle consists of two single blocks with fall fixed to the one, then rove through the other, and then through the first. Power = $\frac{1}{2}$ weight (or 2 to 1): or Power = $\frac{1}{3}$ weight (or 3 to 1). *Vide Fig.* 3, *and* 4.

Two double blocks are generally used for very heavy guns.

A luff tackle, or half watch tackle, consists of one double and one single block: the fall is fixed to the single, then rove through first sheave of the double, then through sheave of single, and lastly through second sheave of double block. Power = $\frac{1}{3}$ weight (3 to 1): or Power = $\frac{1}{4}$ weight (4 to 1). *Vide Fig.* 5, *and* 6.

A runner tackle is the same as a luff tackle applied to the end of a large rope, called a runner, which is rove through a single block attached to a fixed point, or to a body that is to be moved, or raised; the standing end of the runner being secured to another point.

Power is either 6 to 1, or 7 to 1, or 8 to 1.

A gyn tackle consists of one triple and one double block: the fall is fixed to the double, then rove through first sheave of triple, then through first sheave of double, then through second sheave of triple, then through second sheave of double, and lastly through third sheave of triple block.

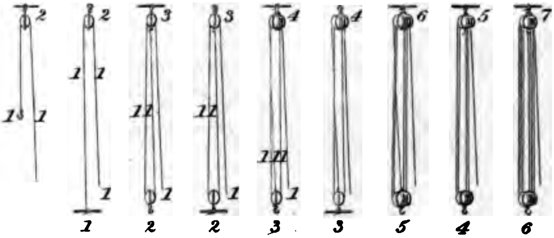
Power = $\frac{1}{5}$ weight (5 to 1); or Power = $\frac{1}{6}$ weight (6 to 1). *Vide Fig.* 7.

If the moveable block of a tackle be strapped with a tail, it is called

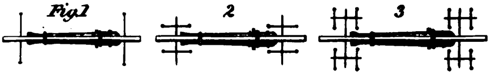
MECHANICS.

System of Pullies

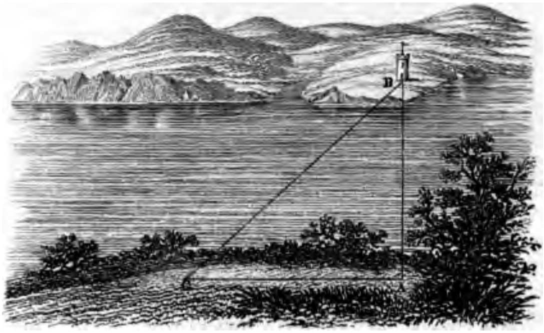
Fig.1 2 3 4 5 6 7 8 9



To carry Guns &c



HEIGHTS AND DISTANCES.



a *tail*, or *jigger block:* and the tackle a *tail*, or *jigger tackle:* a block with a hook strapped to it, and attached to a selvage, answers the same purpose.

Two double blocks, with fall fixed to one of them, and then rove through the sheaves of both blocks, will either give Power = $\frac{1}{4}$ weight (4 to 1): or Power = $\frac{1}{5}$ weight (5 to 1). *Fig.* 8.

Two triple blocks, with fall fixed to one of them, then rove through sheaves of both blocks, will either give power = $\frac{1}{6}$ weight (6 to 1): or Power = $\frac{1}{7}$ weight (7 to 1). *Fig.* 9.

In the system of pulleys (*vide plate, Mechanics*) the Power is shown at the hooks of the moveable blocks, which are to be applied to the bodies, or weights, requiring to be moved, or raised. The strain is also shown at the fixed blocks.

In Fig. 3, there are *three parts of the rope engaged* in supporting the weight—*viz.*, *the parts marked* 1, 1, 1. Each of them, hence, sustains *one-third* of it, and the fall of the rope to which the power is to be attached requires the Power = 1, if weight = 3. The same principle of calculation is applicable to all systems of pulleys having one fixed block, any number of moveable wheels, and a single rope over all the wheels. Hence, in such a system of pulleys, gravity being applied, there will be an equilibrium, when the weight is as many times the power as there are portions of the rope employed in sustaining the weight. *For example*, in a system consisting of six moveable sheaves, the same rope going over them all, there will be 12 portions of the rope engaged; and to produce an equilibrium the power must be equivalent to $\frac{1}{12}$ the weight, no allowance being made for friction.

From the foregoing observations, and by referring to the plate, it will be seen that *each tackle has two applications*, differing in power one from the other; *for example*, if the double block of a luff tackle is fixed to a weight to be moved, and the single block to a picket, or other fastening, *Fig.* 6, then if *one man* haul on the fall, the power of *four men* will be applied to the weight (4 to 1), and the power of *three men* to the picket; but if the double block be fixed to the picket, *Fig.* 5, and the single block to the weight, then the force of only *three men* will be applied to the weight (3 to 1), and a power of *four men* to the picket, or fastening.

When the moveable block of one tackle is fixed to the fall of another tackle, their respective powers are to be multiplied into each other for the power of the combination: thus, if one luff tackle is fixed to the fall of another luff tackle (the double blocks of both tackles being moveable), the power will be 4 × 4 = 16 (16 to 1); in this, the men haul through 16 feet to move the weight one foot; therefore if the combination be increased until the men haul through 100 feet to move the weight one foot, then the power would be 100 to 1.

The foregoing powers are, however, only true in theory, and are, therefore, called *theoretical powers:* for owing to the great friction of *the pulleys, the stiffness* of the ropes, &c., the actual practical powers *are far less;* so much so, that with a combination giving power of 48

to 1, a 24-pr. ($2\frac{1}{2}$ tons weight) suspended, can scarcely overhaul the fall, the friction being so very great.

THE INCLINED PLANE.

The inclined plane forms simply a gradual and sloping instead of a sudden and perpendicular ascent, by which heavy bodies may be raised to certain heights. The power necessary for raising a weight depends on the difference between the length of the plane, and the height to be ascended. If the height be one-third of the length, then one pound will lift three pounds. The force with which a rolling body descends on an inclined plane, is to the force of its absolute gravity, as the height of the plane, is to its length.

Parbuckling a gun on skids unites the advantage of one moveable pulley with that of the inclined plane.

Rule.—As the length of the plane, is to its height, so is the weight, to the power.

Example.—Required the power necessary to raise 540 lb. up an inclined plane, five feet long, and two feet high.

As 5 : 2 : : 540 : 216 lb. *Ans.*

THE WEDGE.

The wedge may be considered as two equally inclined planes joined together at their bases. It has a great advantage over all the other powers, arising from the force of percussion, or blow, with which the back is struck; which is a force incomparably greater than any dead weight, or pressure, such as is employed in other machines. The largest masses of timber may by this means be riven, and vessels of war, weighing many thousand tons, are lifted from their supports by the power of a few men, exerted by blows of mallets on wedges inserted for that purpose.

The power of the wedge increases in proportion as its angle is acute. In tools intended for cutting wood the angle is commonly about 30°; for iron from 50° to 60°; and for brass from 80° to 90°.

Case 1.—*When two bodies are forced from one another, by means of a wedge, in a direction parallel to its back.*

Rule.—As the length of the wedge is to half its back, or head, so is the resistance, to the power.

Example.—The breadth of the back, or head of the wedge, being 3 inches, and the length of either of its inclined sides 10 inches, required the power necessary to separate two substances, with a force of 150 lb.

As 10 : $1\frac{1}{2}$: : 150 : $22\frac{1}{2}$ lb. *Ans.*

Case 2.—*When only one of the bodies is moveable.*

Rule.—As the length of the wedge, is to its back, or head, so is the resistance, to the power.

Example.—The breadth, length, and force, the same as in the last example.

As 10 : 3 : : 150 : 45 lb. Ans.

THE SCREW.

The screw is a spiral thread or groove cut round a cylinder, and everywhere making the same angle with the length of it. The force of a power applied to turn a screw round is to the force with which it presses upward, or downward, setting aside the friction, as the distance between two threads is to the circumference where the power is applied; or the advantage gained is as much as the circumference of a circle described by the handle of the winch exceeds the interval, or distance, between the spirals of the screw. Hence the force of any machine turned by a screw can readily be computed; for instance, in a press driven by a screw, whose threads are each a quarter of an inch asunder, and with a handle, to turn the screw, four feet long; then, if the natural force of a man, by which he can lift, pull, or draw, be 150 lb., and it is required to determine with what force the screw will press when the man turns the handle with his whole force; the diameter of the handle (*power*) being 4 feet, or 48 inches, its circumference is $48 \times 3 \cdot 1416$, or $150\frac{4}{5}$ nearly; and the distance of the threads being one-fourth of an inch, therefore the power is to the pressure as 1 to $(150\frac{4}{5} \times 4) = 603\frac{1}{5}$, but the power is equal to 150 lb., therefore as $1 : 603\frac{1}{5} :: 150 : 90480$, and consequently the pressure is equal to a weight of 90480 lb. independent of friction.

COMPOUND MACHINES.

Though each of the mechanical powers is capable of overcoming the greatest possible resistance in theory, yet in practice, if used singly for producing very great effects, they would frequently be so unwieldy and unmanageable as to render it impossible to apply them. For this reason it is generally found more advantageous to combine them together, by which means the power is more easily applied, and many other advantages are obtained. In all the mechanical powers, and their combinations, and in all machines, simple as well as compound, *what is gained in power is lost in time, or velocity;* and *vice versâ*, or in other words, the product of the power, and the space through which it moves, is equal to the product of the weight, and the space through which it moves in the same plane. Suppose that a man, by means of a fixed pulley, raises a beam to the top of a house in two minutes, it is clear that he will be able to raise six beams in twelve minutes; but by means of a tackle with three lower pulleys, he will raise the six beams at once with the same ease as he before raised one, but then he will be six times as long about it, that is, twelve minutes: thus the work is performed in the same time whether the mechanical power is used, or not. But the convenience gained by the power is very great; for if the six beams are joined in one, they may be raised by the tackle, though it would be impossible to move them by the unassisted strength of one man. No real gain of force is obtained by mechanical contrivances; on the contrary, from *friction* and other causes, force is always lost; but by *machines* a more convenient direction can be given to the moving

power, and so modify its energy as to obtain effects which it could not otherwise produce.

FRICTION.

Friction arises from the irregularities of the surfaces which move upon one another. The surfaces of bodies of the same nature are moved with more facility over each other than those of a dissimilar nature. In proportion as the surfaces which are to be moved upon one another are rough, a greater force is requisite to produce motion. The same surfaces when under a greater pressure, are subject to still further friction. A double pressure doubles the amount of friction, a treble pressure trebles, and so on in nearly the same proportion. When surfaces are moving along each other in the direction of their grains, the friction is greater than when the direction of the grains is at right angles. Friction is little influenced by the velocity with which bodies move upon one another. Friction may be diminished in various ways, as will appear by the result of the following experiment with a block of square stone weighing 1080 lb. :—

	lb.
1. In order to drag this stone along the floor of a quarry roughly chiselled, it required a force equal to . . .	758
2. Over a floor of planks, ditto	652
3. Placed on a platform of wood, and dragged over a floor of planks	606
4. After soaping the two surfaces of wood, which slide over each other	182
5. Placed on rollers of three inches diameter, and moved along the floor of the quarry	34
6. To drag it on these rollers over a wooden floor . . .	28
7. Mounted on a wooden platform, and the same rollers placed between the platform, and a plank floor	22

One of the most remarkable instances of the application of rollers is the transport of the rock which now serves as the pedestal of the equestrian statue of Peter the Great at St. Petersburg. This rock is a single block of granite weighing 1217 tons. A railway was formed, consisting of two lines of timber, furnished with hard metal grooves; similar, and corresponding metal grooves were fixed to the under side of the sledge, or frame, on which the stone was laid, and between these grooves were placed spheres of hard brass, about six inches in diameter. On these spheres the frame with its enormous load was easily moved by sixty men working at capstans with triple purchase blocks.

UNGUENTS.

Mr. G. Rennie found, from a mean of experiments, with different unguents, on axles in motion, and under different pressures, that, with the unguent tallow under a pressure of from 1 to 5 cwt., the friction did not exceed $\frac{1}{36}$th of the whole pressure; when soft soap was applied, it became $\frac{1}{34}$th; and with the softer unguents applied, such as oil, hogs' lard, &c., the ratio of the friction to the pressure increased; but with

the harder unguents as soft soap, tallow, and anti-attrition composition, the friction considerably diminished; consequently, to render an unguent of proper efficiency, the nature of the unguent must be measured by the pressure, or weight, tending to force the surfaces together.

TRANSVERSE STRENGTH OF MATERIALS.

When a beam, of any material, is loaded, the surface in contact with the load is *compressed*, and the opposite surface *extended*; and there is a line between these, which is neither compressed, nor extended, called *the neutral line.*

If the depth of a beam be doubled, the breadth, and length between supports remaining the same, *its strength will be increased four times.*

If its breadth be doubled, the other dimensions being as above, *its strength will be doubled.*

By increasing the distance between the supports of any beam, its strength is decreased in the same ratio; twice the distance between the supports will weaken the beam one half; half the distance between the supports will enable it to bear twice the load.*

The same beam will bear twice the load, if, instead of being concentrated in the middle, it be equally distributed over the whole length of the beam.

If the load on a beam be placed near to one of the supports, instead of in the middle, its effect will decrease in the ratio of its proximity to the support.

Let S s represent the beam, W the load or weight in the middle, w the weight near s; then the load which the beam will carry at the point where w is placed will be found by the following proportion:—

$$\text{As } S\,w \times w\,s : S\,W \times W\,s :: W : w.$$

A beam, fixed at one end, and loaded at the other, will bear half the weight of one of the same length supported at each end.

If the end of a beam, instead of being only supported, be *fixed*, its strength will be in the proportion of 3 to 2.

From the foregoing results it will be seen that the strength of a rectangular beam varies, as the breadth multiplied by the depth squared, divided by the length, $\frac{b \times d^2}{l}$; and if the breaking weight of any material, 1 inch square, and 1 foot long, be found, it will represent a *constant multiplier* for the above equation.

Thus the breaking weight of a beam of Riga fir, 1 inch square, and 1 foot long (*vide following* TABLE), is ·164 of a ton; and to find the breaking weight of a beam of any other dimensions, the rule is simply $W = \frac{b\,d^2}{l} \times \cdot 164.$

* *To strengthen a beam, &c., which is required to support a great weight over a cavity, or ditch.* Place a prop, or short skid, under the centre of the beam, and pass a strong rope, or chain, over the beam lengthways, and under the skid, hauling it very tight, and making fast.

Example.—What will be the breaking weight of a beam of Riga fir, 8 inches broad, 12 inches deep, and 20 feet long?

$$\frac{8 \times 12^2}{20} = 57 \cdot 6 \quad 57 \cdot 6 \times \cdot 164 = 9 \cdot 44 \text{ tons, breaking weight.}$$

Table of constants, for beams of different materials, being the breaking weights of such beams, 1 inch square, and 1 foot long.

Riga fir . . .	·164 of a ton.	English oak . .	·248 of a ton.
Red pine . .	·199 ,,	Canadian do. .	·261 ,,
Pitch pine . .	·242 ,,	Dantzic do. .	·219 ,,
Beech . . .	·231 ,,	Teak	·366 ,,
Elm	·150 ,,	Cast iron, mean .	1·000 ,,
Ash	·301 ,,	Wrought do. .	1·083 ,,

From the foregoing rules

$$\begin{cases} \text{Length} = \dfrac{b\,d^2}{W} \times \text{constant.} \\[2ex] \text{Breadth} = \dfrac{l\,W}{d^2} \times \text{constant.} \\[2ex] \text{Depth} = \sqrt{\dfrac{l\,W}{b}} \times \text{constant.} \end{cases}$$

The practical weight that a beam will carry *with safety*, permanently, should only be taken at one-fourth of the above computations.

Note.—Result of experiments made by Mr. Arman, ship-builder, at Bordeaux, to ascertain the strength of mahogany, as compared with French oak, and teak.

A piece of each kind of wood, about four inches square, was placed across the machine used for proving chain cables, and a piece of chain was attached to a ring fixed in the centre of it. A strain being laid on, the oak broke under a force of 1,800 kilogrammes (about 3,960 lb.); the teak with that of 3,300 (about 7,260 lb.); and the Honduras mahogany of 3,400 (about 7,480 lb.). The oak and teak appeared as if crushed, but without a complete disjunction of the fibres; the mahogany showed long splinters, indicating a much longer grain or fibre than the others.

ADHESION OF NAILS, AND SCREWS.

The percussive force required to drive the common sixpenny nail (73 to the pound) to the depth of an inch and a half into deal, with a weight of six pounds and a quarter, is four blows, or strokes, falling freely the space of one foot; and *the steady pressure* to produce the same effect is four hundred pounds. A *sixpenny nail* driven into dry elm to the depth of one inch across the grain requires a force of 327 pounds to extract it; and the same nail, driven into the same wood endways, or longitudinally, can be extracted with a force of 257 pounds.

To extract a sixpenny nail from a depth of one inch out of dry oak requires 507 pounds, and out of dry beech 667 pounds. A sixpenny nail driven two inches into dry oak would require a steady force of more than half a ton to extract it.

A common screw of one-fifth of an inch diameter has an adhesive force of about three times that of a sixpenny nail.

GRAVITY.

Gravity is downward pressure, or weight, being the natural tendency of all bodies towards the centre of the earth. (*Vide Gravity,* MOTION, FORCES. *Page* 356.)

Absolute gravity denotes the whole force with which a body tends downwards, as when the body is in empty space.

Specific gravity denotes the relative or comparative gravity of any body, in respect to that of another body of equal bulk, or magnitude.

Centre of gravity is that point in a body, or system of bodies, on which, if rested, or suspended, the whole would remain in a state of equilibrium about that point.

The centre of gravity of a circle, regular polygon, prism, cylinder, or sphere, is in its centre.

The centre of gravity of a triangle is found by bisecting any two of its sides, and drawing lines from the points of bisection to the opposite angles; the intersection of these lines will be the centre of gravity.

Force of gravity, or *gravitation*, is an accelerated velocity, which bodies acquire in falling freely from a state of rest.

1. The space through which a body will fall in feet, in any given time equals the product of the square of the time multiplied by 16·0833.

Example.—Required the space a falling body will pass through in five seconds?

$$16 \cdot 0833 \times 25 = 402 \cdot 0825 \text{ feet.}$$

2. The velocity in feet, which a body in descending freely will acquire in a given time, equals the product of the time in seconds multiplied by 32·1666.

Example.—What is the velocity acquired at the end of seven seconds?

$$32 \cdot 1666 \times 7 = 225 \cdot 1662 \text{ feet.}$$

3. The velocity in feet per second that a body will acquire, in falling through a given space, equals the square root of the product of the time multiplied by 64·3333.

Example.—The space through which a body has fallen is 201 feet; required its velocity at the end of the fall?

$$\sqrt{64 \cdot 3333 \times 201} = \sqrt{12931} \text{ nearly} = 1137 \text{ feet.}$$

SPECIFIC GRAVITIES OF SEVERAL SOLID, AND FLUID BODIES.

Air,* in a mean state	1·232	Brick	2000
Brass, cast . . .	8000	Coal*	1250

* 3 inch cube full of air floats 1 lb. in water.
3 inch cube of water weighs 1 lb. in air.
1 cubic foot of water weighs 64 lb. in air.
1 ditto coal ditto 80 – 64 = 16 in water.
1 ditto sand ditto 95 – 64 = 31 in water.

A suit of clothes and a pair of boots, which weigh 7 lb. in air, when well saturated with water, only weigh in water 1 lb.

2 A

Copper	9000	Silver, standard	10535
Cork	240	Steel	7850
Clay	2160	Stone, common	2520
Earth, common	1984	Tin	7320
Flint	2570	Water, rain	1000
Gold, standard	18888	* sea	1030
Gun metal	8784	Wood—alder	800
Gunpowder—solid	1745	ash, the trunk	845
,, loose	868	beech	852
Granite	3000	elm, and larch	540
Iron, cast	7425	fir, Riga, & maple	750
Lead	11325	pine, pitch & red	660
Pitch	1150	oak	950
Sand*	1520	walnut	671

As a cubic foot of water weighs 1000 ounces avoirdupois, the numbers, in the above Table, express not only the specific gravities of the several bodies, but also the weight of a cubic foot of each, in avoirdupois ounces; and therefore, by proportion, the weight of any other quantity, or the quantity of any other weight may be found.

To find the Magnitude of any body from its weight.

As the tabular specific gravity of the body
is to its weight, in avoirdupois ounces;
so is one cubic foot (or 1728 cubic inches)
to its content in feet, or inches, respectively.

To find the Weight of a body, from its magnitude.

As one cubic foot (1728 cubic inches)
is to the content of a body;
so is its tabular specific gravity
to the weight of the body.

To find the Specific gravity of a body.

1.—*When the body is heavier than water.*

Weigh it both in water, and out of water, and take the difference:

Then,—As the weight lost in water
is to the whole, or absolute weight;
so is the specific gravity of water
to the specific gravity of the body.

2.—*When the body is lighter than water*, so that it will not sink, annex to it another body heavier than water, so that the mass compounded of the two may sink together. Weigh the denser body, and the compound mass separately, both in water, and out of it; then find how much each loses in water, by subtracting its weight in water from its weight in air; and subtract the less of these remainders from the greater.

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* See note, page 353.

Then,—As the last remainder
is to the weight of the light body in air;
so is the specific gravity of water
to the specific gravity of the body.

3.—*For a Fluid of any sort.*

Take a piece of a body of known specific gravity, weigh it both in, and out of the fluid, finding the loss of weight by taking the difference of the two:—

Then,—As the whole, or absolute weight
is to the loss of weight;
so is the specific gravity of the solid
to the specific gravity of the fluid.

To find the Quantities of two ingredients in a given compound.

Take the three differences of every pair of the three specific gravities, namely, the specific gravities of the compound, and each ingredient, and multiply each specific gravity by the difference of the other two:

Then,—As the greatest product
is to the whole weight of the compound;
so is each of the other two products
to the weights of the two ingredients.

To find the Diameter of any small sphere, or globule, whose specific gravity is given (or can be found in the Table) and weight known.

Divide its weight in grains by the number expressing its specific gravity; extract the cube root of this quotient, and multiply it by 1·9612 for the diameter.

WEIGHT OF A CUBIC FOOT OF THE FOLLOWING MATERIALS, *in pounds.*

Ash	49	Gravel	120
Beech	43	Granite	166
Birch	49	Brick, common	98
Box	60	Chalk	145
Cork	15	Coal, Newcastle	78
Elm	36	Antimony	418
Fir	30	Brass, cast	525
Mahogany, Spanish	50	Copper	538
Pine, red	41	Gold, pure	1203
Teak	41	Iron, cast, variable	444
Walnut	41	Lead	717
Coke	46	Silver, standard	644
Clay	125	Tin	455
Earth, loose	95		

By means of the foregoing table, the weight of any quantity of the *materials specified* (in cubic feet) may readily be found.

MOTION, FORCES, &c.

Body is the mass, or quantity of matter in any material substance, and it is always proportional to its weight, or gravity, whatever its figure may be.

Density is the proportional weight, or quantity of matter in any body.

Velocity, or celerity, is an affection of motion by which a body passes over a certain space in a certain time.

Momentum, or quantity of motion, is the power, or force, in moving bodies.

Force is a power exerted on a body to move it, or to stop it. If the force act constantly, it is a *permanent force,* like pressure, or the force of gravity; but if it act instantaneously, or for an imperceptibly short time, it is called *impulse,* or *percussion,* like the smart blow of a hammer.

A motive, or moving force, is the power of an agent to produce motion.

Accelerative, or retardative force, is that which affects the velocity only, or it is that by which the velocity is accelerated, or retarded.

The change, or alteration of motion by any external force, is always proportional to that force, and in the direction of the right line in which it acts.

If a body be projected in free space, either parallel to the horizon, or in an oblique direction, by the force of gunpowder, or any other impulse: it will, by this motion, in conjunction with the action of gravity, describe the curve line of a parabola.

A parabola is the section formed by cutting a cone, with a plane, parallel to the side of the cone.

Gravity (*vide page* 353) is a force of such a nature that all bodies, whether light, or heavy, fall perpendicularly through equal spaces in the same time, abstracting the resistance of the air; as lead, and a feather; which, in an exhausted receiver, fall from the top to the bottom in the same time. The velocities acquired by descending, are in the exact proportion of the times of descent, and the spaces descended are proportional to the squares of the times, and, therefore, to the squares of the velocities. Hence, then, it follows that the weights or gravities of bodies near the surface of the earth are proportional to the quantities of matter contained in them; and that the spaces, times, and velocities generated by gravity, have the relations contained in the three general proportions before laid down.

A body in the latitude of London falls nearly $16\frac{1}{12}$ feet in the first second of time, and consequently, at the end of that time, it has acquired a velocity double, or of $32\frac{1}{6}$ feet.

The times being as the velocities, and the spaces as the squares of either; therefore,

if the times be as the Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10;
the velocities will also be as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10;

and the spaces as their squares 1, 4, 9, 16, 25, 36, 49, 64, 81, 100;
and the spaces for each time, 1, 3, 5, 7, 9, 11, 13, 15, 17, 19.

Namely, as the series of the odd numbers, which are the differences of the squares denoting the whole spaces. So that if the first series of natural numbers be seconds of time,

namely, the times in seconds . .	1	2	3	4,	&c.
the velocities in feet will be . .	$32\frac{1}{6}$	$64\frac{1}{3}$	$96\frac{1}{2}$	$128\frac{2}{3}$,	&c.
the spaces in the whole times . .	$16\frac{1}{12}$	$64\frac{1}{3}$	$144\frac{3}{4}$	$257\frac{1}{3}$,	&c.
and the space for each second . .	$16\frac{1}{12}$	$48\frac{1}{4}$	$80\frac{5}{12}$	$112\frac{7}{12}$,	&c.

of which spaces the common difference is $32\frac{1}{6}$ feet, the natural, and obvious measure of the force of gravity.

Thus, a body falling from a state of rest acquires a velocity to pass through 9 spaces in the fifth second of time; 7 in the fourth; 5 in the third; 3 in the second; and 1 in the first. Thus it is $9 + 7 + 5 + 3 + 1 = 25$, which shows that the whole spaces passed through in 5 seconds equal the square of 5.

The momentum, or force, of a body falling through the atmosphere is the mass, or weight, multiplied by the square root of the height it has fallen through, multiplied by 8·021.

Suppose a weight of 10 tons to be raised 9 feet, and to drop thence suddenly on a bridge; the momentum is $10 \times (3 \times 8{\cdot}021) = 240{\cdot}63$ tons. That is, a weight of 10 tons, so falling, would exert as great a strain to break down the bridge, as the pressure of 240·63 tons of dead weight.

Thus, a one-ounce ball falling from a height of 400 feet, would strike the earth with a momentum of

$$\overset{\text{oz.}}{1} \times (\overset{\text{feet.}}{20} \times 8{\cdot}021) = \overset{\text{oz.}}{160{\cdot}42} = \overset{\text{lb.}}{10{\cdot}026}.$$

By experiments to ascertain the effect of Carnot's vertical fire, it was found that 4-oz. balls only penetrated $\frac{1}{20}$ of an inch into deal board, and from 2 to 3 inches into meadow ground.

Amplitude signifies the range of a projectile, or the right line upon the ground, subtending the curvilinear path in which it moves.

The time of flight of different shot and shells is equal to the time a heavy body takes to descend freely from the highest point described by the curve of the projectile.

To find the Time of descent:

Divide the given height, or altitude, by $16\frac{1}{12}$ and the square root of the quotient will be the time required. Thus, if the altitude is 1200 feet, and the time of descent is required,

$1200 \div 16\frac{1}{12} = 74{\cdot}61$, the square root of which is 8·637, the time required.

When a body is projected vertically *downwards* with a given velocity, the space described is equal to the time multiplied by the velocity, together with the product of $16\frac{1}{12}$ by the square of the time; but, if the body is *projected upwards*, the latter product must be subtracted *from the former.*

PRACTICAL GEOMETRY.

DEFINITIONS.*

A line is perpendicular to another when it inclines not more on the one side than on the other, the angles on both sides being equal.

Parallel lines are those which have no inclination to each other, being everywhere equi-distant, however far produced, or extended.

An angle is the inclination, or opening of two lines which meet in a point called the *vertex, or angular point:* and the two lines are called the *legs, or sides* of the angle.

The measure of an angle is estimated by the number of degrees contained in the arc between its two legs.

A rectilinear angle has its legs, or sides, *right,* or straight lines.

A curvilinear angle has its legs *curves.*

A right angle is formed by one line perpendicular to another; the measure of which is an arc of 90°.

An acute angle is less than a right angle, or than 90°.

An obtuse angle is greater than a right angle.

An oblique angle may be either acute, or obtuse.

The circumference, or periphery of a circle is the curved line which bounds it, being everywhere equally distant from the *centre.* The circumference is supposed to be divided into 360 degrees (marked thus °); each degree into 60 minutes, each minute (′) into 60 seconds (″).

An arc is any part of the circumference of a circle.

A chord, or subtense, is a right line joining the extremities of an arc.

The radius of a circle is a right line drawn from the centre to the circumference.

The diameter of a circle is a right line drawn through the centre, and terminated by the circumference.

A semi-circle (180°) is that part of a circle, which is contained between the diameter, and half the circumference.

A quadrant is the fourth part of a circle, being contained between two radii, and an arc of 90°.

A segment is that part of a circle which is cut off by a chord.

A sector is that part of a circle contained between two radii, and an arc.

A secant is a line which cuts a circle, lying partly within, and partly without it.

A tangent is a line which touches a circle, or curve without cutting it.

The point of contact is where a tangent touches an arc.

Triangles are figures having three sides, and three angles.

An equilateral triangle has its three sides equal.

An isosceles triangle has only two equal sides.

A scalene triangle has all its sides unequal.

A rectangular, or right-angled triangle has one of its angles a right

* *Vide also Definitions*—TRIGONOMETRY, page 381.

one, or 90°; and the square of the side opposite the right angle is equal to the sum of the squares of the sides containing that angle; hence a triangle, having its sides proportional to the numbers 3, 4, 5, will be right-angled.

The hypothenuse is the side opposite the right angle in a rectangular triangle.

An obtuse-angled triangle has one of its angles obtuse.

An acute-angled triangle has all its angles acute.

The three angles of any triangle, taken together, are equal to two right angles, or 180°.

The difference of the squares of two sides of a triangle is equal to the product of their sum, and difference.

The sides of a triangle are proportional to the sines of their opposite angles.

Quadrangles, or quadrilaterals are plane figures bounded by four right lines.

A square is a quadrilateral having all its sides equal, and all its angles right angles. The *diagonal of a square* is equal to the square root of twice the square of its sides; and *the side of the square* is equal to the square root of half the square of its diagonal.

The diagonal is a right line drawn across a quadrilateral figure, from one angle to another. The sum of the squares of the two diagonals of every parallelogram is equal to the sum of the squares of the four sides.

A parallelogram is a quadrilateral, whose opposite sides are parallel.

A rectangle is a parallelogram having four right angles.

A rhomboid is an oblique-angled parallelogram.

A rhombus, or lozenge, is a quadrilateral, whose sides are all equal, but its angles oblique.

A trapezium is a quadrilateral, which has none of its sides parallel to each other.

A trapezoid is a quadrilateral, which has only two of its sides parallel.

Polygons are plane figures bounded by more than four sides.

A regular polygon has all its sides, and angles equal.

The perimeter of a figure is the sum of all its sides.

To bisect—is to divide into two equal parts.

To trisect—is to divide into three equal parts.

To inscribe—is to draw one figure within another, so that all the angles of the inner figure touch either the angles, sides, or planes of the external figure.

To circumscribe—is to draw a figure round another, so that either the angles, sides, or planes of the circumscribing figure touch all the angles of the figure within it.

LINES, ANGLES, AND FIGURES.

To divide a given right line into two equal parts.

From the extremities of the line as centres, and with any opening in *the compasses*, greater than half the given line, as a radius, describe

arcs intersecting each other above, and below the given line. A line being drawn through these intersections will divide the given line into two equal parts.

An arc of a circle is bisected in the same manner.

To erect a perpendicular.

From the point A set off any length 4 times to C: from A as a centre with 3 of those parts describe an arc at B, and from C with 5 of them cut the arc at B. Draw A B, which will be the perpendicular required. Any equimultiples of these numbers, 3, 4, 5, may be used for erecting a perpendicular. *Plate* 2, HEIGHTS and DISTANCES, and PRACTICAL GEOMETRY, *Fig.* ½.

To erect a perpendicular.

Set off on each side of the point A, any two equal distances, A D, A E. From D, and E as centres, and with any radius greater than half D E, describe two arcs intersecting each other in F. Through A, and F draw the line A F, and it will be the perpendicular required.

Fig. 1.—*Plate,* PRACTICAL GEOMETRY.

To let fall a perpendicular.

From D as a centre, and with any radius, describe an arc intersecting the given line. From the points of intersection C, and E, with any radius greater than half, describe two arcs, cutting each other at F. Through D, and F draw a line, and D F will be the perpendicular required. *Fig.* 2.

To draw a line parallel to a given line.

From any point D in the given line with the radius D C, describe the arc C E, and from C with the same radius describe the arc D F. Take E C, and set it off from D to F. Through C, and F draw C F for the parallel required. *Fig.* 3.

To divide an angle into two equal parts.

From B as a centre with any radius describe an arc A C. From A, and C with any radius describe arcs intersecting each other in D. Then draw B D, and it will bisect the angle. *Fig.* 4.

To divide a right angle into three equal parts.

From B as a centre with any radius describe the arc A C. From A with the radius A B cut the arc A C in D, and with the same radius from C cut it in E. Then through the intersections D, and E draw the lines B D, B E, and they will trisect, or divide the angle into three equal parts. *Fig.* 5.

To find the centre of a circle.

Draw any chord A B, and bisect it by the perpendicular C D. Divide C D into two equal parts, and the point of bisection O will be the centre required. *Fig.* 6.

PRACTICAL GEOMETRY.

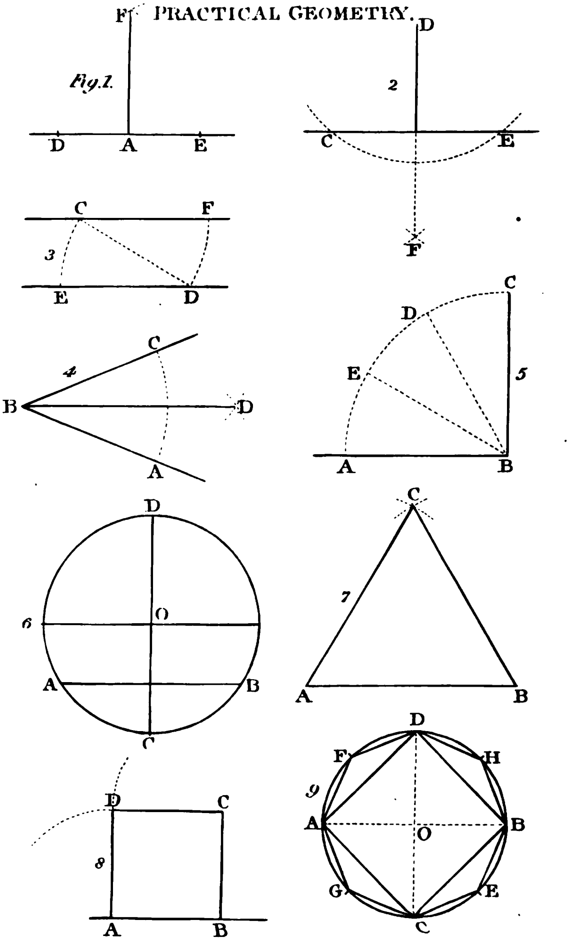


Fig. 10.

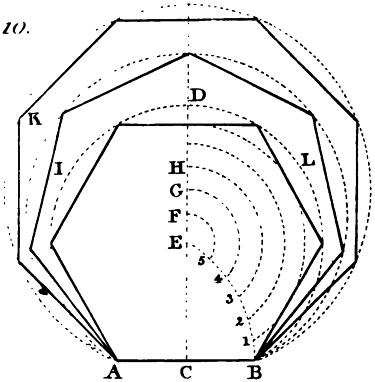
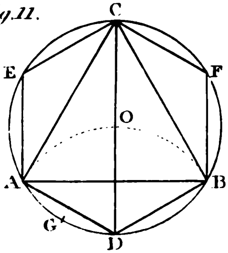


Fig. 11.



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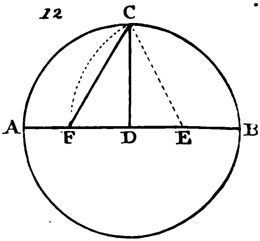

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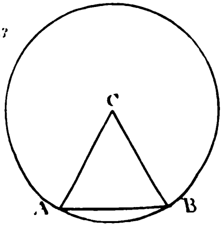

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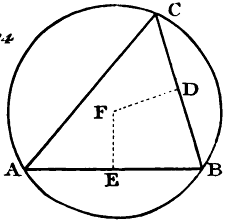


To describe an equilateral triangle.

From the points A, B, as centres, and with A B as radius, describe arcs intersecting each other in C. Draw C A, C B, and the figure A B C will be the triangle required. *Fig.* 7.

To describe a square.

From the point B, draw B C perpendicular, and equal to A B. On A, and C, with the radius A B, describe arcs cutting each other in D. Draw the lines D A, D C, and the figure A B C D will be the square required. *Fig.* 8.

To inscribe a square in a circle.

Draw the diameters A B, C D perpendicular to each other. Then draw the lines A D, A C, B D, B C; and A B C D will be the square required. *Fig.* 9.

To inscribe an octagon in a circle.

Bisect any two arcs A C, B C of the square A B C D in G, and E. Through the points G, and E, and the centre O draw lines, which produce to F, and H. Join A F, F D, D H, &c., and they will form the octagon required. *Fig.* 9.

On a line to describe all the several polygons, from the hexagon to the dodecagon.

Bisect A B by the perpendicular C D. From A as a centre, and with A B as a radius, describe the arc B E, which divide into six equal parts; and from E as a centre describe the arcs 5 F, 4 G, 3 H, &c. Then from the intersection E as a centre, and with E A as a radius, describe the circle A I D B, which will contain A B six times. From F in like manner as a centre, and with F A as radius, describe the circle A K L B, which will contain A B seven times; and so on for the other polygons. *Fig.* 10.

To inscribe in a circle an equilateral triangle.

From any point D in the circumference as a centre, and with the radius D O of the given circle, describe an arc A O B cutting the circumference in A, and B. Through D, and O draw D C. Then, join A B, A C, B C; and the figure A B C will be the triangle required. *Fig.* 11.

To inscribe a hexagon in a circle.

Bisect the arcs A C, B C in E, and F, and join A D, D B, B F, &c., which will form the hexagon. Or carry the radius six times round the circumference, and the hexagon will be obtained. *Fig.* 11.

To inscribe a dodecagon in a circle.

Bisect the arc A D of the hexagon in G, and A G being carried twelve times round the circumference, will form the dodecagon. *Fig. 11.*

To inscribe a pentagon, hexagon, or decagon, in a circle.

Draw the diameter A B, and make the radius D C perpendicular to A B. Bisect D B in E. From E as a centre, and with E C as radius, describe an arc cutting A D in F. Join C F, which will be the side of the pentagon, C D that of the hexagon, and D F that of the decagon. *Fig.* 12.

To find the angles at the centre, and circumference of a regular polygon.

Divide 360 by the number of the sides of the given polygon, and the quotient will be the angle at the centre; and this angle being subtracted from 180°, the difference will be the angle, at the circumference, required.

Table, showing the angles at the centre, and circumference.

Names.	No. of sides.	Angles at centre.	Angles at circumference.
Trigon	3	120°	60°
Tetragon	4	90°	90°
Pentagon	5	72°	108°
Hexagon	6	60°	120°
Heptagon	7	51° $25\frac{5}{7}'$	128° $34\frac{2}{7}'$
Octagon	8	45°	135°
Nonagon	9	40°	140°
Decagon	10	36°	144°

To inscribe any regular polygon in a circle.

From the centre C draw the radii C A, C B, making an angle equal to that at the centre of the proposed polygon, as contained in the preceding table. Then the distance A B will be one side of the polygon, which, being carried round the circumference the proper number of times, will complete the polygon required. *Fig.* 13.

To circumscribe a circle about a triangle.

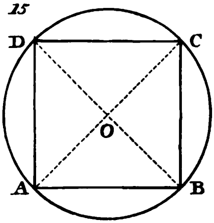
Bisect any two of the given sides, A B, B C by the perpendiculars E F, D F. From the intersection F as a centre, and with the distance of any of the angles, as a radius, describe the circle required. *Fig.* 14.

To circumscribe a circle about a square.

Draw the two diagonals A C, B D intersecting each other in O. From O as a centre, and with O A, or O B, as a radius, describe the required circle. *Fig.* 15.

To circumscribe a square about a circle.

Draw the two diameters A B, C D perpendicular to each other, through the points A, C, B, D, draw the tangents E F, E G, G H, F H, and E G H F will be the square required. Fig. 16.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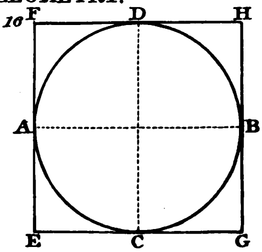
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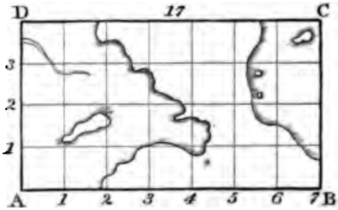
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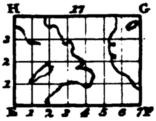
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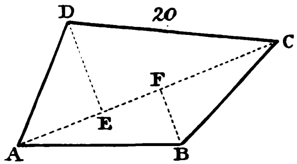
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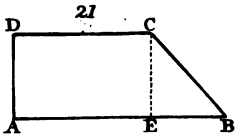
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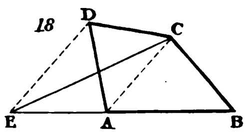
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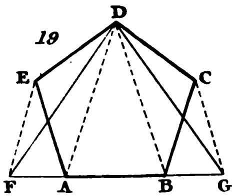
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To reduce a map, or plan, from one scale to another.

Divide the given figure A C by cross lines, forming as many squares as may be thought necessary. Draw a line E F, on which set off as many parts from the scale M, as A B contains parts of the scale N. Draw E H, and F G perpendicular to E F, and each equal to the proportional parts contained in A D, or B C. Join H G, and divide the figure E G into the same number of squares as the original A C. Describe in every square what is contained in the corresponding square of the given figure; and E F G H will be the reduced plan required. The same operation will serve either to reduce, or enlarge any map, plan, drawing, or painting. *Fig.* 17.

To make a triangle equal to a given quadrilateral A B C D.

Draw the diagonal A C, and parallel to it D E, meeting B A produced at E, and join C E: then will the triangle C E B be equal to the given quadrilateral A B C D. *Fig.* 18.

To make a triangle equal to a given pentagon A B C D E.

Draw D A and D B, and also E F, C G parallel to them, meeting A B produced at F and G; then draw D F and D G, so shall the triangle D F G be equal to the given pentagon A B C D E. *Fig.* 19.

Observation.—As the area of every triangle is equal to the product of half its perpendicular height, multiplied by its base, the area of any irregular rectilineal figure can be readily obtained by the foregoing problems.

MENSURATION OF PLANES, AND SOLIDS.

Mensuration is of three kinds, viz., lineal, superficial, and solid.

Lineal measure has reference to length only.

Superficial measure (*or the surface*) includes length, and breadth.

Solid measure (*or the content*) comprehends length, breadth, and thickness.

MENSURATION OF PLANES.

The area of any plane figure is the superficial measure contained within its extremes, or bounds. This area is estimated by the number of small squares that may be contained in it, the side of these measuring squares being an inch, a foot, or any other fixed quantity, and hence the area is said to be so many square inches, square feet, &c. *Vide Table, Square measure. Page* 322.

To find the area of a parallelogram, whether a square, rectangle, &c.

Multiply the length by the breadth, or perpendicular height, for the area required.

Example.—Required the area of a rectangle, whose length is 9 feet, and breadth 4 feet.

$9 \times 4 = 36$ feet. The required area, or surface.

To find the area of a triangle, its base, and perpendicular height being given.

Multiply the base by the perpendicular height, and half the product will be the area.

Example.—Required the number of square yards contained in a triangle, whose base is 20 yards, and perpendicular height 14 yards.

$$\frac{20 \times 14}{2} = 140 \text{ square yards. Area required.}$$

To find the area of a triangle, whose three sides are given.

From half the sum of the three sides, subtract each side severally; multiply the half sum, and the three remainders together, and the square root of the product will be the area required.

Example.—Required the area of a triangle, whose sides are 50, 40, and 30 feet.

$\frac{50 + 40 + 30}{2} = 60$, half the sum of the three sides.

$60 - 30 = 30$ First difference.

$60 - 40 = 20$ Second difference.

$60 - 50 = 10$ Third difference.

$30 \times 20 \times 10 \times 60 = 360000$.

Square root of $360000 = 600$. Area required.

Two sides of a right-angled triangle being given, to find the third side.

1. When the two sides forming the right angle are given, to find the hypothenuse, or side opposite the right angle.

Take the square root of the sum of the two sides squared for the side required.

Example.—Required the length of the interior slope of a rampart, whose perpendicular height is 17 feet, and the base of the slope 20 feet.

$$\begin{aligned} 17 \times 17 &= 289 \\ 20 \times 20 &= 400 \\ \hline \end{aligned}$$

The square root of $689 = 26 \cdot 24$. The length required.

2. When the hypothenuse, and one of the perpendicular sides are given.

From the square of the hypothenuse, subtract the square of the given side, and the square root of the remainder will be the side required.

Example.—The hypothenuse being 5 yards, and the base 4 yards, required the other side.

$$\begin{aligned} 5 \times 5 &= 25 \\ 4 \times 4 &= 16 \\ \hline \end{aligned}$$

The square root of $9 = 3$ yards. The side required.

To find the area of a trapezium, A B C D.

Draw the diagonal A C, upon which let fall from its opposite angles B, and D, the perpendiculars B F, D E. Find by measurement the diagonal A C, and the perpendiculars B F, D E, then multiply the sum of the perpendiculars by the diagonal, and half the product will be the area of the trapezium.—*Fig.* 20, *Plate* 3, *Practical Geometry.*

Example.—Required the area of the trapezium, whose diagonal A C is 100 feet, and perpendiculars B F 30 feet, and D E 40 feet.

$$\frac{\overline{30+40}\times 100}{2} = 3500 \text{ square feet. Area required.}$$

Or divide the trapezium into two triangles by a diagonal, then find the areas of these triangles, and add them together.

To find the area of a trapezoid, A B C D.

Multiply the sum of the parallel sides A B, D C by the perpendicular distance E C, and half the product will be the area. *Fig.* 21, *Plate* 3, *Practical Geometry.*

Example.—Required the area of the trapezoid A B C D, of which the parallel sides A B, D C are 120 feet, and 90 feet, and the perpendicular distance E C 40 feet.

$$\frac{\overline{120+90}\times 40}{2} = 4200 \text{ square feet. Area required.}$$

To find the area of an irregular figure, or polygon.

Draw diagonals dividing the figure into trapeziums, and triangles; then, having found the area of each, add them together, and the sum will be the area required.

To find the area of a figure, having a part bounded by a curve.

Draw a right line joining the extremities of the curve, then find the area of the trapezium. On the right line let fall as many perpendiculars as the several windings of the curve may require. Find their lengths, and divide their sum by the number of perpendiculars, and the quotient will be the mean breadth; which being multiplied by the length of the right line, will give the area of the curved part. This area being added to that of the trapezium will give the area of the required figure.

To measure long irregular figures.

Measure the breadth at both ends, and at several places *at equal distances.* Add together all these intermediate breadths, and half the two extremes, which sum multiply by the length, and divide by the number of parts of the area. If the perpendiculars, or breadths, be *not at equal distances,* compute all the parts separately, as so many *trapezoids,* and add them all together for the whole area.

Example.—The breadths of an irregular figure at five equidistant places being 8, 2, 7, 9, 4, and the whole length 40, required the area.

$$8+4=12 \qquad 12\div2=6$$
$$6+2+7+9=24$$
$$\frac{24\times40}{4}=240.\ \text{Area required.}$$

*To find the number of square acres in any of the preceding figures.**

Divide the superficial content in feet by 43560 (or in yards by 4840), and the quotient will be the number required.

To bring square chains to acres.

Of square chains strike off one decimal place to the right, and the rest of the figures will be acres.

To bring square links to acres, roods, and perches.

Of square links cut off five of the figures on the right hand, for decimals, and the rest will be acres; then multiply these decimals by 4, for roods, cutting off five figures as before; and the decimals of these again by 40, for perches, when five figures are again to be struck off.

To find the area of a regular polygon.

Multiply the *perimeter* (or sum of the sides) of the polygon by the perpendicular drawn from its centre on one of its sides, and take half the product for the area.

Or, multiply the area of one of the triangles by the number of sides of the polygon, and the product will be the area of it.

Example.—Required, the area of a regular hexagon, whose side is 40 feet, and the perpendicular 34·64 feet.

$$40\times6=240 \text{ the perimeter.}$$
$$\frac{240\times34\cdot64}{2}=4156\cdot8 \text{ square feet. Area required.}$$

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* *Gunter's chain* is in length 4 poles = 22 yards = 66 feet, and is divided into 100 links. Each link is therefore $\frac{22}{100}$ of a yard, or $\frac{66}{100}$ of a foot, or 7·92 inches. *Land is estimated* in acres, roods, and perches. *An acre* contains 10 square chains, or as much as 10 chains in length and 1 chain in breadth; or in yards it is $220\times22=4840$; or in poles it is $40\times4=160$ square poles; or in links it is $1000\times100=100,000$ square links. An acre is divided into 4 parts called roods, and a rood into 40 parts called perches, which are square poles, or the square of a pole of $5\frac{1}{2}$ yards long, or the square of a quarter of a chain, or of 25 links, which is 625 links. Thus the divisions of land measure are—

625 square links	=	1 pole, or perch.
40 perches	=	1 rood.
4 roods	=	1 acre.

The length of lines, measured with a chain, should be set down in links as integers, instead of in chains, and decimals. Therefore, after the content is found, it will be in square links.

To find the diameter, and circumference of any circle, the one from the other.

Use either of the following proportions:

$$\left.\begin{array}{l}\text{as 7 is to 22}\\ \text{or as 1 is to 3·1416}\end{array}\right\}\left\{\begin{array}{l}\text{so is the diameter}\\ \quad\text{to the circumference.}\end{array}\right.$$

$$\left.\begin{array}{l}\text{as 22 is to 7}\\ \text{or as 3·1416 is to 1}\end{array}\right\}\left\{\begin{array}{l}\text{so is the circumference}\\ \quad\text{to the diameter.}\end{array}\right.$$

Or, instead of dividing the diameter by 3·1416 multiply it by ·3183, for the circumference.

Example 1.—Required, the circumference of a circle, whose diameter is 20 feet.

As 7 : 22 : : 20 : 62·857 feet. Circumference required.

Example 2.—Required, the diameter of a circle, whose circumference is 36 inches.

As 22 : 7 : : 36 : 11·45 inches. Diameter required.

To find the diameter of a circle, the area being given.

Divide the area by ·7854, and the square root of the quotient will be the diameter required.

Example.—Required, the diameter of a circle, whose area is 176·715 square feet.

176·715÷7854 = 225.

Square root of 225 = 15 feet. Diameter required.

To find the area of a circle.

1. Multiply half the circumference by half the diameter, or multiply the whole circumference by the whole diameter, and take $\frac{1}{4}$ of the product.

2. Or, square the diameter, and multiply that square by ·7854 for the area.

3. Or, square the circumference, and multiply that square by ·07958.

Example 1.—Required the area of a circle, whose circumference is 55·548 inches, and its diameter 18 inches.

$$\frac{55 \cdot 548}{2} = 27 \cdot 774 \text{ half circumference.}$$

$$\frac{18}{2} = 9 \text{ half diameter.}$$

27·774 × 9 = 249·966, square inches. Area required.

Example 2.—Required the area of a circle whose diameter is 12 feet.

12 × 12 = 144, square of the diameter.

·7854 × 144 = 113·0976 square feet. Area required.

Example 3.—Required the area of a circle, whose circumference is 22 feet.

$$22 \times 22 = 484.$$
$$484 \times \cdot 07958 = 38 \cdot 51672 \text{ square feet. Area required.}$$

To find the area of a circular ring,

or space included between the circumferences of two circles, the one within the other.

1. Subtract the square of the less diameter from the square of the greater, and multiply their difference by ·7854.

2. Or, find the area of each circle separately, and subtract one from the other, for the area required.

3. Or, multiply the sum of the diameters by the difference of the same, and that product by ·7854 for the area.

Example.—Required the area of a ring, the diameters of whose bounding circles are 10, and 20.

By Rule 3.

$$20 + 10 = 30, \text{ sum of diameters.}$$
$$20 - 10 = 10, \text{ difference of diameters.}$$
$$30 \times 10 \times \cdot 7854 = 235 \cdot 62. \text{ The area.}$$

To find the length of any arc of a circle.

1. As 360° is to the number of degrees in the arc, so is the circumference to the length of the arc.

2. Or, multiply the degrees in the given arc by the radius of the circle, and the product by ·01745 for the length of the arc.

Example.—*Rule* 2.—Required the length of an arc of 30°, the radius being 9 feet.

$$30 \times 9 \times \cdot 01745 = 4 \cdot 7115. \text{ Length of arc.}$$

To find the area of the sector of a circle.

Multiply the radius by the arc, and half the product will be the area.

Example.—Required the area of the sector, whose radius is 30 inches, and the length of the arc 36·6 inches.

$$\frac{36 \cdot 6 \times 30}{2} = 549 \text{ square inches. Area required.}$$

To find the area of the segment of a circle.

Find the area of the sector, by the preceding rule. Then find the area of the triangle formed by the chord of the segment, and the radii of the sector. Then, if the segment be less than a semicircle, subtract the area of the triangle from it; or, if the segment be greater than a semicircle, add the area of the triangle to it; for the area of the segment.

Example.—Required the area of a segment less than a semicircle, the radius being 20 inches, the chord 22·42 inches, the length of the arc 24·43 inches, and the perpendicular 16·56 inches.

$$\frac{24 \cdot 43 \times 20}{2} = 244 \cdot 3 \text{ square inches. Area of the sector.}$$

$$\frac{22 \cdot 42 \times 16 \cdot 56}{2} = 185 \cdot 6376 \left\{ \begin{array}{l} \text{square inches.} \\ \text{Area of the triangle.} \end{array} \right.$$

$$244 \cdot 3 - 185 \cdot 6376 = 58 \cdot 6624 \left\{ \begin{array}{l} \text{square inches.} \\ \text{Area required.} \end{array} \right.$$

To find the area of a semicircle.

1. Multiply ½ of the circumference by the radius, and the product will be the area.

2. Or, multiply the square of the diameter by ·7854, and half the product will be the area.

Example.—*Rule* 2.—Required the area of a semicircle, the diameter being 50 inches.

$$\frac{50 \times 50 \times \cdot 7854}{2} = 981 \cdot 75 \left\{ \begin{array}{l} \text{square inches.} \\ \text{Area required.} \end{array} \right.$$

To find the area of an ellipsis, or oval.

Multiply the longest diameter, or axis, by the shortest, then multiply the product by ·7854 for the area.

Example.—Required the area of the ellipse, whose diameters are 25 inches, and 18 inches.

$$25 \times 18 \times \cdot 7854 = 353 \cdot 43 \text{ square inches. Area required.}$$

To find the area of a parabola, or its segment.

Multiply the base by the perpendicular height, and take two-thirds of the product for the area.

Example.—Required the area of a parabola, whose base is 20 feet, and height 12 feet.

$20 \times 12 = 240$
$\frac{2}{3}$ of $240 = 160$ square feet. Area required.

MENSURATION OF SOLIDS.

A solid is a body containing length, breadth, and thickness.

Solids are measured by cubes, whose sides are each an inch, a foot, a yard, &c., and the solidity, capacity, or content of any figure is computed by the number of such cubes as are contained in it.—Vide CUBIC MEASURE, *page* 320.

A cube is a solid contained by six equal square sides.

A pyramid is a solid whose sides are all triangles meeting together

in a point, the base being any plane figure whatever. It is called a triangular pyramid when its base is a triangle; a square pyramid when its base is a square, &c.

The segment of a pyramid, cone, or any other solid is a part, D E F G, cut off from the top, by a plane D E F, parallel to the base A B C.— *Vide Fig.* 21, *Plate* 2, HEIGHTS, DISTANCES, and PRACTICAL GEOMETRY.

A frustrum, or trunk, is a part, A B C D E F, that remains at the bottom after the segment is cut of.

A cone is a round pyramid, of which the base is a circle.

The axis of a solid is a line from the vertex (or point) to the centre of the base, or through the centres of the two ends. When the axis is perpendicular to the base, it is a right prism, pyramid, or cone; otherwise it is oblique.

A sphere is a solid contained under one convex surface and is described by the revolution of a semicircle about its diameter which remains fixed.

The centre of the sphere is such a point within the solid as is everywhere equally distant from the convex surface, or circumference of it.

The diameter (or axis) of a sphere is a straight line, which passes through the centre, and is terminated by the convex surface.

A segment of a sphere is a part cut off by a plane, the section of which is always a circle, called the *base of the segment*.

A sector of a sphere is that which is composed of a segment (less than a hemisphere) and of a cone.

A prism is a solid, the sides of which are parallelograms, having its ends equal, and similar plane figures.

Prisms are named according to the number of angles in the base.

A cylinder is a solid, the two ends of which are circular; and it is described, or formed, by the revolution of a right-angled parallelogram about one of its sides, which remains fixed.

To find the superficies of a prism, or cylinder.

Multiply the perimeter of one end of the prism by the length, or height of the solid, and the product will be the surface of all its sides. To which add also the area of the two ends of the prism, when required.

Or, compute the areas of all the sides and ends separately, and add them all together.

Example.—Required the surface of a cube, whose sides are each 5 inches.

$5 + 5 + 5 + 5 = 20$, perimeter of one end.
$20 \times 5 = 100$, surface of sides.
$5 \times 5 = 25$, area of one end.
$100 + 25 + 25 = 150$ square inches. Surface of cube.

To find the surface of a pyramid, or cone.

Multiply the perimeter of the base by the slant height, or length of

the side, and half the product will be the surface of the sides; to which add the area of the base when required.

Example.—Required the upright surface of a triangular pyramid, the slant height being 20 feet, and each side of the base 3 feet.

$3 + 3 + 3 = 9$, perimeter of base.
$9 \times 20 = 90$ feet. Surface required.

To find the surface of the frustrum of a pyramid, or cone.

Add together the perimeters of the two ends, multiply their sum by the slant height, and take half the product.

Example.—How many square feet are in the surface of the frustrum of a square pyramid, whose slant height is 10 feet, each side of the base 3 feet, and each side of the less end 2 feet?

$3 + 3 + 3 + 3 = 12$, perimeter of base.
$2 + 2 + 2 + 2 = 8$, perimeter of less end.

$$\frac{\overline{12 + 8} \times 10}{2} = 100 \text{ feet. Surface required.}$$

To find the solid content of a prism, or cylinder.

Find the area of the base, or end, and multiply it by the length of the prism, or cylinder. For a cube, multiply its side twice by itself; and for a parallelopipedon, multiply the length, breadth, and depth together for the content.

Example.—Required the solid content of a cube, whose side is 24 inches.

$24 \times 24 \times 24 = 13824$ square inches. Content required.

To find the content of the solid part of a hollow cylinder.

From the content of the whole cylinder considered as a solid, subtract the content of the hollow part, also considered as a solid, and the difference will be the solidity required.

Example.—Required the content of the solid part of the hollow cylinder whose exterior diameter is 12 inches, the interior diameter 8 inches, and height 20 inches.

$12 \times 12 \times \cdot7854 = 113\cdot0976$, area of base of cylinder.
$113\cdot0976 \times 20 = 2261\cdot952$, solidity of whole cylinder.
$8 \times 8 \times \cdot7854 = 50\cdot2656$, area of base of hollow cylinder.
$50\cdot2656 \times 20 = 1005\cdot312$, content of hollow part.
$2261\cdot952 - 1005\cdot312 = 1256\cdot64$ cubic inches. Solidity required.

To find the solidity of the frustrum of a cylinder.

Multiply the area of the base by half the greatest, and the least lengths, and the product will be the solidity.

Example.—Required the solidity of a frustrum, whose diameter is 24 inches, the greatest length 36 inches, and the least length 20 inches.

$24 \times 24 = 576$. Square of the diameter.
$576 \times \cdot 7854 = 452 \cdot 3904$. Area of the base.

$$452 \cdot 3904 \times \frac{36 + 20}{2} = 12666 \cdot 9312 \left\{ \begin{array}{l} \text{Cubic inches.} \\ \text{Solidity required.} \end{array} \right.$$

To find the content of a pyramid, or cone.

Find the area of the base, and multiply that area by the perpendicular height, and take $\frac{1}{3}$ of the product.

Example.—Required the solidity of a square pyramid, each side of its base being 30, and its perpendicular height 25.

$$30 \times 30 = 900, \text{ area of base.}$$

$$\frac{900 \times 25}{3} = 7500, \text{ Solidity required.}$$

To find the solidity of the frustrum of a cone, or pyramid.

Add into one sum the areas of the two ends, and the mean proportional between them: take $\frac{1}{3}$ of that sum for the mean area, which multiply by the perpendicular height, or length of the frustrum.

Note.—To find a mean proportional.

As one of the sides of the base is to the homologous, or corresponding side of the other end, so is the area of the base to the mean proportional required.

Example.—Required the number of solid feet in a piece of timber, whose bases are squares, each side of the greater end being 15 inches, and each side of the less end 6 inches; also the length of the perpendicular altitude 24 feet.

$15 \times 15 = 225$, area of the base.
$6 \times 6 = 36$, area of the top.
As $15 : 6 :: 225 : 90$, mean proportional.
24 feet = 288 inches.

$$\frac{\overline{225 + 36 + 90} \times 288}{3} = 33696 \text{ cubic inches} = 19\tfrac{1}{2} \text{ cubic feet.}$$

To find the surface of a sphere, or any segment.

Multiply the circumference of the sphere by its diameter, which will give the whole surface.

Or, square the diameter, and multiply by $3 \cdot 1416$.
Or, square the circumference, and multiply by $\cdot 3183$;
„ „ and divide by $3 \cdot 1416$.

Note.—For the surface of the segment, or frustrum, multiply the whole circumference of the sphere by the height of the part required.

Example.—Required the superficies of a globe whose diameter is 24 inches.

$$24 \times 24 \times 3 \cdot 1416 = 1809 \cdot 5616 \text{ square inches.}$$

To find the solidity of a sphere or globe.

1. Multiply the surface by the diameter, and take $\frac{1}{6}$ of the product.

Or, multiply the square of the diameter by the circumference, and take $\frac{1}{6}$ of the product.

2. Cube the diameter, and multiply by ·5236.
3. Cube the circumference, and multiply by ·01688.

Example.—Required the content of a sphere, whose axis is 12.

$12 \times 12 \times 12 \times \cdot 5236 = 904 \cdot 7808.$ Content required.

To find the solidity of a hemisphere.

Find the solidity of the sphere, and half the content will be that of the hemisphere.

Note 1.—Any sphere, or globe *twice* the diameter of another contains *four times* the superficies, or area of the other, and *eight times* the solid content. Hence the superficies of spheres are as the squares, and the solidity as the cubes of their diameters.

Note 2.—The cube of the diameter of a sphere in inches, multiplied by ·00188, will give the number of *imperial gallons it will contain.*

To find the solid content of a spherical segment.

1. From three times the diameter of the sphere, take double the height of the segment; then multiply the remainder by the square of the height, and this product by ·5236.

2. Or, to three times the square of the radius of the segment's base add the square of its height; then multiply the sum by the height, and the product by ·5236.

Example.—Required the content of a spherical segment 2 feet in height, cut from a sphere of 8 feet diameter.

$(3 \times 8) - (2 + 2) = 20$
$20 \times 2^2 \times \cdot 5236 = 41 \cdot 888$ cubic feet. Content required.

To find the diameter of a sphere, its solidity being given.

Divide the solidity by ·5236, and take the cube root of the quotient.

Example.—The solidity of a sphere being 113·0976 solid inches, what will be its diameter?

$\dfrac{113 \cdot 0976}{\cdot 5236} = 216$, the cube root of which is 6 inches, the diameter required.

To find the weight of an iron shot, its diameter being given.

Take $\frac{1}{8}$ of the cube of the diameter, and $\frac{1}{8}$ of that eighth, and the sum of these two quotients will be the weight in pounds.

Or, as 64 is to 9 lb., so is the diameter cubed to its weight.

Example.—Required the weight of an iron shot whose diameter is 3·5 inches?

3·5 cubed $= 42{\cdot}875$, cube of diameter.

$$\frac{42{\cdot}875}{8} = 5{\cdot}359 \qquad \frac{5{\cdot}359}{8} = {\cdot}669$$

$5{\cdot}359 + {\cdot}669 = 6{\cdot}028$ pounds. Weight required.

To find the weight of a leaden ball, its diameter being given.

Take $\frac{1}{3}$ of the cube of the diameter, and from it subtract $\frac{1}{3}$ of this third, and the remainder will be the weight, nearly.

Or, take $\frac{3}{14}$ of the cube of the diameter.

Example.—What is the weight of a leaden ball whose diameter is 3·3 inches?

3·3 cubed $= 35{\cdot}937$, cube of diameter.

$$\frac{35{\cdot}937}{3} = 11{\cdot}979 \qquad \frac{11{\cdot}979}{3} = 3{\cdot}993$$

$11{\cdot}979 - 3{\cdot}993 = 7{\cdot}986$ pounds. Weight required.

To find the diameter of an iron shot, its weight being given.

Multiply the cube root of the shot's weight by 1·923 for the diameter.

Pr.	Cube root.		Diameter.
42	3·4760, &c.	Multiplied by 1·923, diameter of a 1 lb. shot.	6·684, &c.
32	3·1748		6·103 „
24	2·8844		5·545 „
18	2·6207		5·038 „
12	2·2894		4·401 „
9	2·0800		3·999 „
6	1·8171		3·494 „
3	1·4422		2·772 „

To find the diameter of a leaden ball, its weight being given.

To 4 times the weight add half the weight, and $\frac{3}{100}$ of half the weight; and the cube root of this sum will be the diameter in inches, nearly.

Example.—What is the diameter of a leaden ball, whose weight is 8 pounds.

$8 \times 4 = 32 \qquad \frac{8}{2} = 4 \qquad \frac{3}{100}$ of $4 = {\cdot}12$.

$32 + 4 + {\cdot}12 = 36{\cdot}12$, of which the cube root is 3·3 inches, nearly. Diameter required.

To find the weight of an iron shell, its interior and exterior diameter being given.

Take $\frac{2}{64}$ of the difference of the cubes of the external and internal diameters, for the weight of the shell in pounds.

Example.—What is the weight of a shell whose exterior diameter is 12·85 inches, and interior diameter 8·75 inches?

12·85 cubed = 2121·8241. 8·75 cubed = 669·9218.
2121·8241 − 669·9218 = 1451·9022.
$\frac{2}{64}$ of 1451·9022 = 204·1737 pounds. Weight required.

To find the quantity of powder a shell will contain.

Divide the cube of the interior diameter in inches by 57·3, and the quotient will be the weight in pounds.

Or, multiply the cube of the diameter by 11, and divide by 21 for the quantity in half ounces.

Example.—How much powder will fill a shell, whose internal diameter is 7 inches?

7 cubed = 343.

$$\frac{343}{57{\cdot}3} = 6 \text{ pounds nearly. Powder required.}$$

*To find the side of a cubical box to contain a given quantity of powder.**

Multiply the weight in pounds by 30, and the cube root of the product will be the side of the box in inches.

Example.—Required the side of a cubical box to hold 50 pounds of powder?

50 × 30 = 1500, the cube root of which is 11·44, which will be the side of the box in inches.

To find the quantity of powder to fill the chamber of a mortar, or howitzer.

Multiply the content of the chamber in inches by 55, and divide the product by 1728, and the quotient will be the quantity of powder in pounds.

Note.—The chamber of a mortar, or howitzer, is formed of a hollow frustrum of a right cone, and of a hollow hemisphere.

Example.—Required the quantity of powder to fill the chamber of a 13-inch mortar in which the diameter A B is 9·5 inches, the diameter

* 57·3 is the number of pounds of powder contained in a cubic foot, when shaken; and 55 pounds when not shaken. According to the first case, one pound of powder will occupy 30 cubic inches; and according to the second case, one pound will occupy 31·4182 cubic inches.

C E 6·5 inches, and the length D G 21·5 inches. *Vide Fig.* 22. *Plate* 2. HEIGHTS AND DISTANCES, and PRACTICAL GEOMETRY.

The content of the chamber must be found by finding the content of the hollow frustrum of the cone, and that of the hemisphere (*vide preceding rules*): which in this example will be 999·9741875.

$$\text{Then } \frac{999{\cdot}9741875 \times 55}{1728} = 31 \text{ pounds, nearly.}$$

To find the quantity of powder to fill a rectangular box.

Divide the content (viz., length × breath × depth) of the box in inches by 30 for the pounds of powder.

Example.—How much powder will fill a box, the length being 15 inches, the breadth 12, and the depth 10 inches?

$$\frac{15 \times 12 \times 10}{30} = \frac{1800}{30} = 60 \text{ pounds.} \quad \text{Number required.}$$

To find the quantity of powder to fill a cylinder.

Multiply the square of the diameter by the length, then divide by 38·2 for the pounds of powder.

Example.—How much powder will the cylinder contain, whose diameter is 10 inches, and length 20 inches?

$$\frac{10 \times 10 \times 20}{38{\cdot}2} = 52\tfrac{1}{3} \text{ pounds, nearly.}$$

To find the size of a shell, to contain a given weight of powder.

Multiply the pounds of powder by 57·3, and the cube root of the product will be the diameter in inches.

Example.—Required the diameter of a shell to contain 6 lb. of powder?

6 × 57·3 = 343·8, the cube root of which is 7, the diameter required, in inches.

To find what length of a cylinder (or bore of a gun) will be filled by a given weight of powder.

Multiply the weight in pounds by 38·2, and divide the product by the square of the diameter in inches, for the length required.

Example.—What length of a cylinder 8 inches in diameter will be filled with 20 lb. of powder?

$$\frac{20 \times 38{\cdot}2}{8 \times 8} = 11\tfrac{15}{16} \text{ inches.}$$

To find the content, and weight of a piece of ordnance.

Divide the length of the gun into as many sections as may be found necessary. Find the content of each (*by preceding rules*) and from

their sum subtract the content of a cylinder, whose length is equal to that of the bore, and its diameter equal to that of the calibre of the piece; multiply the difference (if it be a brass gun) by 5·0833, (if an iron gun) by 4·2968, and the product will be the weight in ounces.

Note.—A cubic inch of gun metal weighs 5·0833 ounces.
Ditto of *cast* iron 4·2968 ounces.

To find the content of a cask.

Multiply half the sum of the areas of the two interior circles, viz., at the head, and bung, by the interior length, for the content.

Or, to the area of the head, add twice the area at the bung, multiply that sum by the length, and take one-third of the product.

Example.—Required the content of a cask, its greatest interior diameter being 24 inches, its least interior diameter 20 inches, and the interior length 30 inches.

$24 \times 24 \times \cdot 7854 = 452 \cdot 3904$, area of large circle.
$20 \times 20 \times \cdot 7854 = 314 \cdot 1600$, area of small circle.

$$\frac{452 \cdot 3904 + 314 \cdot 1600}{2} = 383 \cdot 2752, \text{ half sum.}$$

Then $383 \cdot 2752 \times 30 = 11498 \cdot 256$, the content; which being divided by $277\frac{1}{4}$ (the number of cubic inches in a gallon) will give the number of gallons contained in the cask.

Thus $\frac{11498 \cdot 256}{277 \cdot 25} = 41 \cdot 4725$, &c. Number of gallons required.

Note.—The content of any vessel in cubic feet, multiplied by 6·232 (or if in inches by ·003607) will give the number of *imperial gallons it will contain.*

EPITOME OF MENSURATION.

OF THE CIRCLE, CYLINDER, SPHERE, ETC.

1. The circle contains a greater area than any other plane figure, bounded by an equal perimeter, or outline.

2. The areas of circles are to each other as the squares of their diameters; any circle twice the diameter of another contains four times the area of the other.

3. The diameter of a circle being 1, its circumference equals 3·1416.

4. The diameter of a circle is equal to ·31831 of its circumference.

5. The square of the diameter of a circle being 1, its area equals ·7854.

6. The square root of the area of a circle, multiplied by 1·12837, equals its diameter.

7. The diameter of a circle, multiplied by ·8862, or the circumference multiplied by ·2821, equals the side of a square of equal area.

8. The sum of the squares of half the chord, and versed sine, divided by the versed sine, the quotient equals the diameter of the corresponding circle.

9. The chord of the whole arc of a circle taken from eight times the chord of half the arc, one-third of the remainder equals the length of the arc.

10. Or, the number of degrees contained in the arc of a circle, multiplied by the diameter of a circle, and by ·008727, the product equals the length of the arc in equal terms of unity.

11. The length of the arc of the sector of a circle multiplied by its radius, half the product is the area.

12. The area of the segment of a circle equals the area of the sector, minus the area of a triangle whose vertex is the centre, and base equals the chord of the segment.

13. The sum of the diameters of two concentric circles multiplied by their difference, and by ·7854, equals the area of the ring, or space contained between them.

14. The sum of the thickness, and internal diameter of a cylindric ring multiplied by the square of its thickness, and by 2·4674, equals its solidity.

15. The circumference of a cylinder multiplied by its length, or height, equals its convex surface.

16. The area of the end of a cylinder multiplied by its length, equals its solid content.

17. The area of the internal diameter of a cylinder multiplied by its depth, equals its cubical capacity.

18. The square of the diameter of a cylinder multiplied by its length, and divided by any other required length, the square root of the quotient equals the diameter of the other cylinder of equal solidity, or capacity.

19. The square of the diameter of a sphere multiplied by 3·1416, equals its convex surface.

20. The cube of the diameter of a sphere multiplied by ·5236, equals its solid content.

21. The height of any spherical segment, or zone, multiplied by the diameter of the sphere, of which it is a part, and by 3·1416, equals the area, or convex surface of the segment;

22. Or, the height of the segment multiplied by the circumference of the sphere of which it is a part, equals the area.

23. The solidity of any spherical segment is equal to three times the square of the radius of its base, plus the square of its height, and multiplied by its height, and by ·5236.

24. The solidity of a spherical zone equals the sum of the squares of the radii of its two ends, and one-third the square of its height, multiplied by the height, and by 1·5708.

25. The solidity of the middle zone of a sphere equals the sum of the square of either end, and two-thirds the square of the height, multiplied by the height, and by ·7854.

26. The capacity of a cylinder 1 foot in diameter, and 1 foot in length, equals 4·895 imperial gallons.

27. The capacity of a cylinder 1 inch in diameter, and 1 foot in length, equals ·034 of an imperial gallon.

28. The capacity of a cylinder 1 inch in diameter, and 1 inch in length, equals ·002832 of an imperial gallon.

29. The capacity of a sphere 1 foot in diameter, equals 3·263 imperial gallons.

30. The capacity of a sphere 1 inch in diameter, equals ·001888 of an imperial gallon.

31. Hence the capacity of any other cylinder in imperial gallons is obtained by multiplying the square of its diameter by its length; or the capacity of any other sphere by the cube of its diameter, and by the number of imperial gallons contained as above in the unity of its measurement.

OF THE SQUARE, RECTANGLE, CUBE, ETC.

1. The side of a square equals the square root of its area.

2. The area of a square equals the square of one of its sides.

3. The diagonal of a square equals the square root of twice the square of its side.

4. The side of a square is equal to the square root of half the square of its diagonal.

5. The side of a square, equal to the diagonal of a given square, contains double the area of the given square.

6. The area of a rectangle equals its length multiplied by its breadth.

7. The length of a rectangle equals the area divided by the breadth; or the breadth equals the area divided by the length.

8. The side, or end of a rectangle, equals the square root of the sum of the diagonal, and opposite side to that required, multiplied by their difference.

9. The diagonal in a rectangle equals the square root of the sum of the squares of the base, and perpendicular.

10. The solidity of a cube equals the area of one of its sides multiplied by the length of one of its edges.

11. The edge of a cube equals the cube root of its solidity.

12. The capacity of a 12-inch cube equals 6·232 gallons.

Surfaces and Solidities of the regular bodies, when the linear edge is 1.

No. of Sides.	Names.	Surfaces.	Solids.
4	Tetrahedron .	1·7320508	0·1178513
6	Hexahedron .	6·	1·
8	Octahedron . .	3·4641016	0·4714045
12	Dodecahedron .	20·6457788	7·6631189
20	Icosahedron. .	8·6602540	2·1816950

The tabular surface multiplied by the square of the linear edge, the product equals the surface required;

Or, the tabular solidity, multiplied by the cube of the linear edge, the product is the solidity required.

OF TRIANGLES, POLYGONS, ETC.

1. The complement of an angle is its defect from a right angle.
2. The supplement of an angle is its defect from two right angles.
3. The sine, tangent, and secant of an angle, are the cosine, cotangent, and cosecant of the complement of that angle.
4. The hypothenuse of a right-angled triangle being made radii, its sides become the sines of the opposite angles, or the cosines of the adjacent angles.
5. The three angles of every triangle are equal to two right angles; hence the oblique angles of a right-angled triangle are each other's complements.
6. The sum of the squares of the two given sides of a right-angled triangle is equal to the square of the hypothenuse.
7. The difference between the square of the hypothenuse, and given side of a right-angled triangle is equal to the square of the required side.
8. The area of a triangle equals half the product of the base multiplied by the perpendicular height;
9. Or, the area of a triangle equals half the product of the two sides, and the natural sine of the contained angle.
10. The side of any regular polygon multiplied by its apothem, or perpendicular, and by the number of its sides, half the product is the area.

Table of the Areas of regular polygons whose sides are unity.

Name of polygon.	No. of sides.	Apothem, or perpendicular.	Area, when side is one, or unity.	Interior angle.		Central angle.	
				°	′	°	′
Triangle .	3	0·2886751	0·4330127	60	0	120	0
Square .	4	0·5	1·	90	0	90	0
Pentagon .	5	0·6881910	1·7204774	108	0	72	0
Hexagon .	6	0·8660254	2·5980762	120	0	60	0
Heptagon.	7	1·0382607	3·6339124	128	$34\frac{2}{7}$	51	$25\frac{5}{7}$
Octagon .	8	1·2071068	4·8284271	135	0	45	0
Nonagon .	9	1·3737387	6·1818242	140	0	40	0
Decagon .	10	1·5388418	7·6942088	144	0	36	0
Undecagon	11	1·7028436	9·3656399	147	$16\frac{4}{11}$	32	$43\frac{7}{11}$
Dodecagon	12	1·8660254	11·1961524	150	0	30	0

The tabular area of the corresponding polygon multiplied by the square of the side of the given polygon, equals the area of the given polygon.

PART XIV.

TRIGONOMETRY.

Plane trigonometry treats of the relations, and calculations of the sides, and angles of plane triangles.

The measure of an angle is an arc of any circle contained between the two lines which form that angle, the angular point being the centre; and it is estimated by the number of degrees contained in that arc. Hence a right angle being measured by a quadrant, or quarter of a circle, is an angle of 90 degrees. The sum of the three angles of every triangle is equal to 180 degrees, or two right angles; therefore, in a right-angled triangle, taking one of the acute angles from 90 degrees, leaves the other acute angle; and the sum of the two angles in any triangle, taken from 180 degrees, leaves the third angle; or one angle being taken from 180 degrees leaves the sum of the other two angles.

Definitions.

The Sine of an arc is the line drawn from one extremity of the arc perpendicular to the diameter of the circle which passes through the other extremity.

The Versed sine of an arc is the part of the diameter intercepted between the arc, and its sine.

The Supplement of an arc is the difference, in degrees, between the arc, and a semicircle, or 180 degrees.

The Complement of an arc is the difference, in degrees, between the arc, and a quadrant, or 90 degrees.

The Tangent of an arc is a line touching the circle in one extremity of that arc, continued from thence to meet a line drawn from the centre through the other extremity; which last line is called *the Secant* of the same arc.

The Cosine, Cotangent, and Cosecant of an arc are the sine, tangent, and secant of the complement of that arc, *the Co* being only a contraction of the word complement.

The sine, tangent, or secant of an angle, is the sine, tangent or secant of the arc by which the angle is measured, or of the degrees, &c., in the same arc, or angle. *Vide also Definitions*, PRACTICAL GEOMETRY, *page* 358.

There are two Methods of resolving triangles, or the cases of trigonometry—viz., *Construction*, and *Computation.*

1*st method.*—The triangle is constructed by making the sides from

a scale of equal parts, and laying down the angles from the protractor. Then, by measuring the unknown parts by the same scale, the solution will be obtained.

2nd method.—Having stated the terms of the proposition, resolve it like any other proportion, in which a fourth term is to be found from three given terms, by multiplying the second and third terms together, and dividing the product by the first.

Note.—Every triangle has six parts—viz., three sides, and three angles; and, in every case in trigonometry, there must be given three of these parts to find the other three. Also of the three parts that are given, one of them at least must be a side; because, with the same angles, the sides may be greater, or less, in any proportion.

Computation.

Case 1.—*When a side and its opposite angle are two of the given parts.*

The sides of any triangle having the same proportion to each other, as the sines of their opposite angles; then—

As any one side, is to the sine of its opposite angle; so is any other side, to the sine of its opposite angle.

To find an angle, begin the proportion with a side, opposite to a given angle; and, *to find a side,* begin with an angle opposite to a given side.

Case 2.—*When two sides, and their contained angle, are given.*

As the sum of the two sides, is to the difference of the sides, so is the tangent of half the sum of their opposite angles, to the tangent of half the difference, of the same angles. Then by adding half the sum to half the difference the greater angle will be ascertained; and by subtracting half the difference from the half sum, the lesser angle will be determined. All the angles being consequently known, the side required will be found, as in *Case* 1.

Case 3.—*When the three sides of a triangle are given, to find the angles.*

Let fall a perpendicular from the greatest angle, on the opposite side, or base, dividing it into two segments; and the whole triangle into two right-angled triangles: then the proportion will be—

As the base, or sum of the segments, is to the sum of the other two sides; so is the difference of those sides, to the difference of the segments of the bases; then add half the difference of the segments to the half sum, or the half base, for the greater segment; and subtract the same for the less segment. Hence, in each of the two right-angled triangles, there will be known two sides, and the right angle opposite to one of them, consequently the other angle will be found by the method in *Case* 1.

Case 4.—*When in a right-angled triangle, one side and the angles are given, to find the other side, or the hypothenuse.*

As radius (*i.e.*, sine of 90°, or tangent of 45°), is to the given side; so is the tangent of its adjacent angle to the other side: and so is the secant of the same angle to the hypothenuse.

USEFUL THEOREMS, AND COROLLARIES.

1. When one line meets another, the angles, which it makes on the same side of the other, are together equal to two right angles.

2. All the angles, which can be made at any point (by any number of lines), on the same side of a right line, are, when taken all together, equal to two right angles: and, as all the angles that can be made, on the other side of the line, are also equal to two right angles; therefore all the angles that can be made quite round a point, by any number of lines, are equal to four right angles. Hence also the whole circumference of a circle, being the sum of all the angles that can be made, about the centre, is the measure of four right angles.

3. When two lines intersect each other, the opposite angles are equal.

4. When one side of a triangle is produced, or extended, the outward angle is equal to the sum of the two inward opposite angles.

5. In any triangle, the sum of all the three angles is equal to two right angles (180°). Hence, if one angle of a triangle be a right angle, the sum of the other two angles will be equal to a right angle, (90°).

6. In any quadrilateral, the sum of all the four inward angles is equal to four right angles.

7. In any right-angled triangle, the square of the hypothenuse (or side opposite to the right angle) is equal to the sum of the squares of the other two sides. Therefore, *to find the hypothenuse*, add together the squares of the other two sides, and extract the square root of that sum: and *to find one of the other sides*, subtract from the square of the hypothenuse the square of the other given side, and extract the square root of the remainder for the side required.

8. cosine $= \sqrt{}(1 - \text{sin.}^2)$
9. sine $\div$ cosine $=$ tangent.
10. cosine $\div$ sine $=$ cotangent.
11. $\text{sin.}^2 + \text{cos.}^2 = \text{rad.}^2$
12. $\text{rad.}^2 + \text{tan.}^2 = \text{secant.}^2$
13. $1 \div$ tan. $=$ cotangent.
14. $1 \div$ cotan. $=$ tangent.
15. $1 \div$ sine $=$ cosecant.
16. $1 \div$ cosine $=$ secant.
17. $1 \div$ cosecant $=$ sine.
18. $1 \div$ secant $=$ cosine.
19. rad. $-$ cosine $=$ versed sine.

Thus, we may, instead of dividing by a sine, multiply by the cosecant; instead of dividing by a tangent, multiply by the cotangent of the same arc; and so of others.

RIGHT-ANGLED TRIANGLES.

1. $(\text{hypoth.})^2 = \text{base}^2 + \text{perp.}^2$
2. $\text{base}^2 = (\text{hypoth.} + \text{perp.}) \times (\text{hypoth.} - \text{perp.})$

3. $\text{perp.}^2 = (\text{hypoth.} + \text{base}) \times (\text{hypoth.} - \text{base.})$
4. perp. = base × tan. angle at base.
5. hyp. = base × sec. angle at base.
6. perp. ÷ base = tan. angle at base.
7. base ÷ perp. = tan. angle at vertex.
8. hypoth. ÷ base = sec. angle at base.
9. hypoth. ÷ perp. = sec. angle at vertex.
10. base ÷ hypoth. = cosine angle at base.
11. perp. ÷ hypoth. = sine angle at base.

TRIGONOMETRY, WITHOUT LOGARITHMS.*

"In all the more elaborate and refined operations of trigonometry, it is not only desirable, but necessary, to employ some of the larger logarithmic tables, both to save time and to ensure the requisite accuracy in the results. But in the more ordinary operations, as in those of common surveying, ascertaining inaccessible heights, and distances, reconnoitring, &c., where it is not very usual to measure a distance nearer than within about its thousandth part, or to ascertain an angle nearer than within two or three minutes, it is quite a useless labour to aim at greater accuracy in a numerical result. Why compute the length of a line to the fourth or fifth place of decimals, when it must depend upon another line, whose accuracy cannot be ensured beyond the unit's place? Or, why compute an angle to seconds, when the instrument employed does not ensure the angles in the data beyond the nearest minute? In the following Table are brought together the *natural sines and cosines*, &c., to every degree in the quadrant, and this table will be found sufficiently extensive and correct for the various practical purposes above alluded to. The requisite proportions must, it is true, be worked by multiplication, and division, instead of by logarithms. Yet this by no means involves such a disadvantage as might seem at first sight. For when the measured lines are expressed by three, or at most four figures, the multiplications and divisions are performed nearly as quick, and in some cases quicker, than by logarithms. Then as to accuracy, even in cases where the computer will have to take proportional parts for the minutes of a degree, the result may usually, if not always, be relied upon to within about a minute."

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* In Lieut.-Colonel B. Jackson's scientific "Treatise on Military Surveying, &c., &c., &c.," *Portable trigonometry without logarithms*, is thus introduced—

"The following useful application of Trigonometry, by means of the natural sines, tangents, &c., is taken from an early number of that valuable periodical, 'The Mechanic's Magazine,' and will be found particularly suited to the purposes of the military surveyor."

A TABLE OF NATURAL SINES, COSINES, TANGENTS, COTANGENTS, SECANTS, AND COSECANTS,

to every Degree of the Quadrant.

Deg.	Sines.	Cosines.	Tangents.	Cotangents.	Secants.	Cosecants.	Deg.
0	·00000	1·00000	·00000	Infinite.	1·00000	Infinite.	90
1	·01745	·99985	·01745	57·2900	1·00015	57·2987	89
2	·03490	·99939	·03492	28·6363	1·00061	28·7537	88
3	·05234	·99863	·05241	19·0811	1·00137	19·1073	87
4	·06976	·99756	·06993	14·3007	1·00244	14·3356	86
5	·08716	·99619	·08749	11·4301	1·00382	11·4737	85
6	·10453	·99452	·10510	9·51236	1·00551	9·56677	84
7	·12187	·99255	·12278	8·14435	1·00751	8·20551	83
8	·13917	·99027	·14054	7·11537	1·00983	7·18530	82
9	·15643	·98769	·15838	6·31375	1·01246	6·39245	81
10	·17365	·98481	·17633	5·67128	1·01543	5·75877	80
11	·19081	·98163	·19438	5·14455	1·01872	5·24084	79
12	·20791	·97815	·21256	4·70463	1·02234	4·80973	78
13	·22495	·97437	·23087	4·33148	1·02630	4·44541	77
14	·24192	·97030	·24933	4·01078	1·03061	4·13356	76
15	·25882	·96593	·26795	3·73205	1·03528	3·86370	75
16	·27564	·96126	·28675	3·48741	1·04030	3·62796	74
17	·29237	·95630	·30573	3·27085	1·04569	3·42030	73
18	·30902	·95106	·32492	3·07768	1·05146	3·23607	72
19	·32557	·94552	·34433	2·90421	1·05762	3·07155	71
20	·34202	·93969	·36397	2·74748	1·06418	2·92380	70
21	·35837	·93358	·38386	2·60509	1·07114	2·79043	69
22	·37461	·92718	·40403	2·47509	1·07853	2·66947	68
23	·39073	·92050	·42447	2·35585	1·08636	2·55930	67
24	·40674	·91355	·44523	2·24604	1·09464	2·45859	66
25	·42262	·90631	·46631	2·14451	1·10338	2·36620	65
26	·43837	·89879	·48773	2·05030	1·11260	2·28117	64
27	·45399	·89101	·50952	1·96261	1·12233	2·20269	63
28	·46947	·88295	·53171	1·88073	1·13257	2·13005	62
29	·48481	·87462	·55431	1·80405	1·14335	2·06266	61
30	·50000	·86603	·57735	1·73205	1·15470	2·00000	60
31	·51504	·85717	·60086	1·66428	1·16663	1·94160	59
32	·52992	·84805	·62487	1·60033	1·17918	1·88708	58
33	·54464	·83867	·64941	1·53986	1·19236	1·83608	57
34	·55919	·82904	·67451	1·48256	1·20622	1·78829	56
35	·57358	·81915	·70021	1·42815	1·22077	1·74345	55
36	·58778	·80902	·72654	1·37638	1·23607	1·70130	54
37	·60181	·79863	·75355	1·32704	1·25214	1·66164	53
38	·61566	·78801	·78129	1·27994	1·26902	1·62427	52
39	·62932	·77715	·80978	1·23490	1·28676	1·58902	51
40	·64279	·76604	·83910	1·19175	1·30541	1·55572	50
41	·65606	·75471	·86929	1·15037	1·32501	1·52425	49
42	·66913	·74314	·90040	1·11061	1·34563	1·49448	48
43	·68200	·73135	·93251	1·07237	1·36733	1·46628	47
44	·69466	·71934	·96569	1·03553	1·39016	1·43956	46
45	·70711	·70711	1·00000	1·00000	1·41421	1·41421	45
Deg.	Cosines.	Sines.	Cotangents.	Tangents.	Cosecants.	Secants.	Deg.

"The preceding table is so arranged that for angles not exceeding 45 degrees, the sine and cosine for any number of degrees will be found opposite to the proposed number in the left-hand column, and in the column under the appropriate word. When the number of degrees in the arc, or angle, exceeds 45 degrees, that number must be found in the right-hand column, and opposite to it in the column indicated by the appropriate word at the bottom of the table. Thus, the sine, and cosine of 36 degrees are ·58778, and ·80902 respectively; the tangent and cotangent of 62 degrees are 1·88073, and ·53171 respectively; the radius of the table being unity, or 1. The taking of proportional parts for minutes can only be done correctly in those parts of the table where the differences between the successive sines, &c., run pretty uniformly. Suppose we want the natural sine of 20° 16′. The sine of 21 degrees is ·35837, that of 20 degrees is ·34202; their difference is ·01635. This divided by 60 gives ·0002725 for the proportional part due to 1 minute, and that again multiplied by 16 gives ·00436 for the proportional part for 16 minutes. Hence the sum of ·34202 and ·00436, or ·34638, is very nearly the sine of 20° 16′. But the operation may often be contracted by recollecting that 10 minutes are $\frac{1}{6}$, 15 minutes are $\frac{1}{4}$, 40 minutes are $\frac{2}{3}$ of a degree, and so on. Observe, also, that for cosines the results of the operations for proportional parts are to be *deducted* from the value of the required trigonometrical quantity in the preceding degree."

APPLICATION OF TRIGONOMETRY, WITHOUT LOGARITHMS,

to the determination of heights, and distances.

Example 1.—Having measured a distance of 200 feet in a direct horizontal line from the bottom of a steeple, the angle of elevation of its top, taken at that distance, was found to be 47° 30′, from hence it is required to find the height of the steeple?

By deducting 47° 30′ from 90°, the angle opposite the given side will be found (42° 30′).

Then by *Case* 1. TRIGONOMETRY:—

As sine $\angle$ 42° 30′: 200 :: sine $\angle$ 47° 30′:

Or ·67556 : 200 :: ·73723 : 208·2, &c., height required.

By construction—

The triangle is constructed by making the side from a scale of equal parts, and laying down the angles from the protractor. Then by measuring the unknown parts by the same scale, the solution will be obtained.

Example 2.—Being on the side of a river, and requiring the distance to a house on the other side, 200 yards were measured in a straight line by the side of the river, and at each end of this base line the angles with the house were 68° 2′, and 73° 15′—required the distance from each end of the base line to the house?

The sum of the given angles (68° 2′ + 73° 15′) subtracted from 180° will give the third angle (38° 43′).

Then by *Case* 1. TRIGONOMETRY :—

As sine $\angle$ 38° 43′ : 200 : : sine $\angle$ 68° 2′
  ·62544 : 200 : : ·92739 : 296·5, first distance required.

As sine $\angle$ 38° 43′ : 200 : : sine : $\angle$: 73° 15′
  ·62544 : 200 : : ·95753 : 306·1, second distance required.

Similarly to the preceding examples, HEIGHTS, AND DISTANCES may be rapidly (and for military purposes, sufficiently accurately) computed in the field, by means of the foregoing trigonometrical table, if proper attention is paid to the principles by which the unknown angles of triangles may be ascertained: a base line, and requisite angle, or angles, having been given.

It will, however, be necessary to use advantageously the methods in Cases 1, 2, (*vide* TRIGONOMETRY), and also the properties in the subsequent theorems, and corollaries.*

TABLE,

showing the reduction in feet, and decimals upon 100 *feet, for the following angles of elevation, and depression.*

Angle.	Reduction.	Angle.	Reduction.	Angle.	Reduction.
° ′		° ′		° ′	
3 0	·14	9 0	1·22	15 0	3·40
		9 30	1·38	15 30	3·64
4 0	·25	10 0	1·52	16 0	3·88
		10 30	1·68	16 30	4·12
5 0	·38	11 0	1·84	17 0	4·37
		11 30	2·01	17 30	4·63
6 0	·55	12 0	2·19	18 0	4·90
6 30	·65	12 30	2·37	18 30	5·17
7 0	·76	13 0	2·56	19 0	5·44
7 30	·86	13 30	2·77	19 30	5·74
8 0	·98	14 0	2·97	20 0	6·08
8 30	1·10	14 30	3·18	20 30	6·33

The reduction for 100 feet (from the above table) multiplied by the number of times 100 feet measured, will give the quantity to be subtracted from the measured length of an inclination, to reduce it to a horizontal position.

* For further information on Surveying, and Reconnoitring, reference should be made to the highly-valued publication, entitled "A TREATISE ON MILITARY SURVEYING, INCLUDING SKETCHING IN THE FIELD, PLAN DRAWING, LEVELLING, MILITARY RECONNOISSANCE, &c.," by Lieut.-Colonel Basil Jackson, containing a full account of every surveying instrument, and the right adaptation of them.

TABLE,

showing the rate of inclination of inclined planes, for the following angles of elevation.

Angle.	One in	Angle.	One in	Angle.	One in
° ′		° ′		° ′	
0 15	228	3 30	17	7 0	8
0 30	114	3 45	16	7 30	7¼
0 45	76	4 0	15	8 0	7
1 0	56	4 15	14	9 0	6½
1 15	46	4 30	13	10 0	6
1 30	38	4 45	12	11 0	5¾
1 45	32	5 0	11½	12 0	5½
2 0	28	5 15	11	13 0	5
2 15	26	5 30	10½	14 0	4½
2 30	23	5 45	10	15 0	4
2 45	21	6 0	9½	16 0	3¾
3 0	19	6 30	9	17 0	3½
3 15	18	6 45	8½	18 0	3¼

SURVEYING, AND RECONNOITRING.

HEIGHTS, AND DISTANCES.

The accurate determination of heights and distances of objects being required in various military operations, especially for the position of batteries, the following methods for their attainment will be found useful, when the requisite instruments are at hand; by frequent practice the eye should, however, be enabled to determine, *nearly*, either the height of, or distance from, any object.

HEIGHTS.

1.—BY MEANS OF A "POCKET SEXTANT,"

to ascertain the height of an object.

When the sextant is used for taking the height of objects, it is to be held vertically, and the quicksilvered part of the horizon glass will be on the left hand of the observer, or on the left part of the transparent glass. Altitudes are measured in the same manner as horizontal angles, for if we conceive the horizontal triangle A B C (*vide Plate* HEIGHTS AND DISTANCES, *page* 346) to be raised on its base A C with the angle C next to the observer, then the perpendicular A B becomes the height of the object B; and supposing the object to stand on a horizontal plane, then the ground and the object form the right angle at A; therefore, *if the object is accessible*, the sextant need only be set at any of the *angles* mentioned for distances (*vide Art.* DISTANCES), and walking

Surveying, and Reconnoitring.

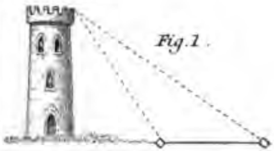


Fig. 1.

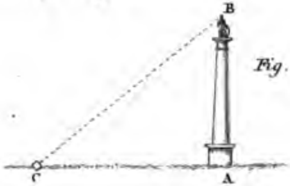


Fig. 2.

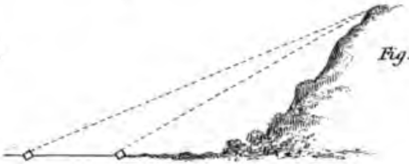


Fig. 3.

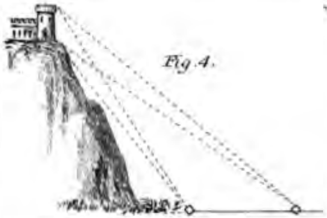


Fig. 4.

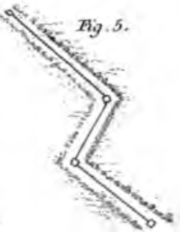


Fig. 5.

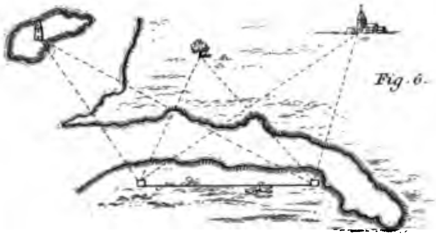


Fig. 6.

J. W. Lowry sc.

backward on the line A C until the top of the object is brought down to the height of the observer's eye from the ground, then the distance from where the observer stands to the object will be in the same proportion to its height as the base was to the distance. Then add the height of the eye from the ground, and the height of the object will be ascertained. If the object is not accessible, the angle must be taken, and calculated by trigonometry.

2.—BY MEANS OF A PORTABLE BAROMETER, AND THERMOMETER, *to ascertain the height of an object.*

Observe the altitude (B) of the mercurial column in inches, tenths, and hundredths, at the bottom of the hill, or other object, the height of which is required.

Observe, also, the altitude (b) of the mercurial column at the top of the object. Observe the temperature on Fahrenheit's thermometer at the times of the two barometrical observations, and take the mean between them. Then $55000 \times \frac{B-b}{B \times b} =$ the height of the hill in feet, for the temperature of 55 degrees on Fahrenheit. Add $\frac{1}{440}$ of this result for every degree which the mean temperature exceeds 55 degrees, and subtract as much for every degree below 55 degrees. This will be a good approximation when the height of the hill is below 2000 feet.

3.—BY MEANS OF THE RECONNOITRING PROTRACTOR,* *to measure the height of an inaccessible object.*

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig.* 1.]

Place yourself at a convenient distance from the object whose height is required, taking care to have a good base line to the second station. Hold the protractor vertically, with a steady hand, the tube side uppermost, and bring the top of the object in a line with the centre of the tube. Allow the arm (or index) to vibrate freely, and, when steady, note the angular height of the object (shown by the edge of the index on the marginal scale of degrees). By the aid of points taken through the tube, or by pickets, then pace, or measure a base in a direct line from the object; and, when arrived at the second station, again note the angular height of the object.

Construction—

Set off the angles, and draw the respective lines, which by their intersection, will determine the height of the perpendicular, to which the height of the protractor above the ground must be added for the altitude of the object. By using the scale of the measured base line, the height required will be ascertained, or it may be calculated by "TRIGONOMETRY, WITHOUT LOGARITHMS."—*Page* 384.

* *Vide* page 393.

To measure the height of an accessible object.

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig.* 2.]

At an appropriate distance from the object, take its angular height, and measure the distance to its base.*

Construction—

Draw a line representing this distance, at one end of which draw another line at the angle found, and at the other erect a perpendicular; the intersection of these lines will determine the altitude of the object.

To measure the vertical height of a hill, or mountain.

[*Fig.* 3, *Plate*, SURVEYING, AND RECONNOITRING.]

From a station a short distance from the hill, take, and note down its angular height; then select a rear position for a base line, using the tube of the protractor to insure a straight direction; proceed to the requisite distance on the base, and again note the altitude of the hill.*

Construction—

The intersection of lines drawn from each end of the base line, at the angles found, will determine the altitude; the perpendicular height of which, added to that of the protractor above the ground, will give the altitude required.

To measure the altitude of a tower, &c., on a height.

[*Fig.* 4, *Plate*, SURVEYING, AND RECONNOITRING.]

From the first station, near the base, take the altitude of the hill, and also that of the tower above it, and note down these angles; proceed to another station in a straight line with the former one, measuring its length, and again observe the angular height of the hill, and also that of the top of the tower.

Similarly to the previously described mode, ascertain, first, the height of the hill; second, the height of the hill, and tower; deduct the first calculation from the second, which will leave the height of the tower.

4.—BY THE SHADOW OF THE OBJECT,

to ascertain the height.

Set up vertically a staff of known length, and measure the length of its shadow upon a horizontal, or other plane; measure also the length of the shadow of the object of which the altitude is required. Then, by the property of similar triangles,

As the length of the shadow of the staff
is to the altitude of the staff,
so is the length of the shadow of the object
to the altitude of the object.

* In all the foregoing cases the heights may be correctly ascertained by trigonometrical calculations (*vide* TRIGONOMETRY, WITHOUT LOGARITHMS, *page* 384).

Plate 2.

HEIGHTS. *No. 4.*

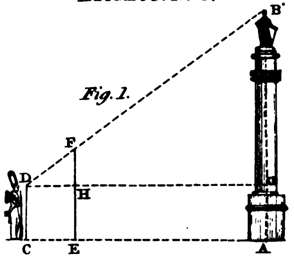


Fig. 1.

HEIGHTS. *No. 5.*

DISTANCES. *No. 6.*

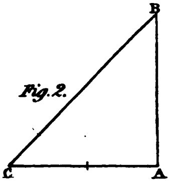
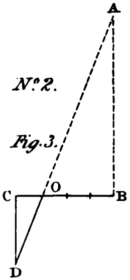


Fig. 2.

DISTANCES.

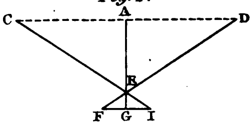
No. 2.

Fig. 3.



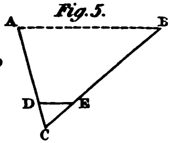
No. 3.

Fig. 4.



No. 4.

Fig. 5.



PRACTICAL GEOMETRY.

Fig. 1.

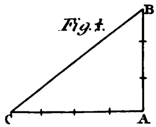


Fig. 21.

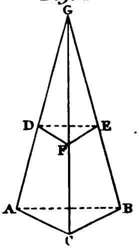
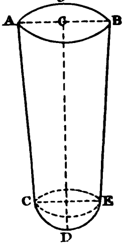


Fig. 22.



5.—WHEN THERE IS NO SHADOW,

to ascertain the height.

Place a staff (equal in length to the height of the observer's eye) vertically at such a distance from the foot of the required altitude, that the observer, having laid himself upon his back, with his feet against the bottom of the stick, may see the top of the staff and object in the same line. Then, by similar triangles, the height may be readily ascertained.

6.—BY MEANS OF THE TANGENT SCALE OF A GUN,

to ascertain the height of an object, the distance being known.

Lay the gun for the top of the object the height of which is required, then raise the tangent scale until the top of it and the notch on the muzzle are in line with the bottom of the object: then, by similar triangles,

As the length of the gun
is to the length of the raised part of the tangent scale,
so is the distance from the gun to the object
to the height required.

7.—BY MEANS OF TWO PICKETS,

to ascertain the height of an object.

[*Vide Plate*, HEIGHTS, AND DISTANCES, *page* 388.]

Let two pickets C D (4 feet), E F (6 feet), be placed with their bases in the line C A passing through A the height required, and move them nearer to, or farther from each other, until the summit B of the object is seen in the same line as D, and F, the tops of the rods. Then, by the principles of similar triangles,

As D H (= C E) : F H : : D G (= C A) : B G.
To which add A G = C D for the whole height A B.

Thus, supposing C E to be 6 feet, F H 2 feet, and C A 150 feet, the proportion will be,

As 6 : 2 : : 150 : 50 feet.
Then 50 + C D will be the altitude required.

DISTANCES.

1.—BY MEANS OF THE SEXTANT,*

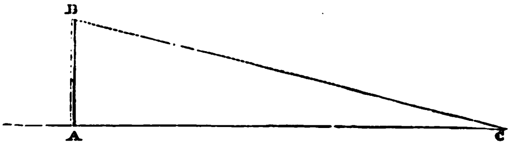
to find the distance from an object, whose height is known.

Let A B represent the height of the object; C your station; and C B the distance to be found.

Take the angle B C A with the sextant,* and note it in minutes;

* Or Reconnoitring protractor.

then A B, in feet $\times$ 573 $\div$ B C A, in minutes = A C in fathoms.
Or A B in feet $\times$ 573 $\div$ B C A, in minutes $\times$ 2 = A C in yards.



573 is a constant multiple.

This method requires no table of sines, &c., the number of minutes in the angle being used instead of the sine.

2.—BY MEANS OF A POCKET SEXTANT,

to measure inaccessible distances.

When used for taking the distance of objects, the sextant is to be held horizontally, and the quicksilvered part of the glass will be uppermost, or above the transparent part.

To ascertain the distance A B (*vide Plate* 2, *Fig.* 2), obtain, by observation, the direction A C perpendicular to A B, which is thus performed:—Set the instrument at 90°, and place yourself at the point A, with your right towards the point B; then look through the sextant, and direct a picket to be placed in the line A C at 100 yards, or feet, from you, so that the point B will appear right above it. Then set the sextant at 45°, and walk along the line towards C until you bring the points A and B to coincide; the base and perpendicular will then be of equal length, and A C being known, or measured, the distance A B will also be ascertained. But if you cannot walk far enough to find angle C 45°, find it equal to 63° 26′, and then A C = $\frac{1}{2}$ A B; at 71° 34′ = $\frac{1}{3}$ A B; at 75° 58′ = $\frac{1}{4}$ A B; at 78° 41′ = $\frac{1}{5}$ A B; at 80° 32′ = $\frac{1}{6}$ A B; at 82° 52′ = $\frac{1}{8}$ A B; and at 84° 17′ the distance will be $\frac{1}{10}$ A B.

Should the object be far distant, it will be necessary to take a long base, and the side A B must be calculated, therefore, by trigonometry.

3.—BY MEANS OF THE PRISMATIC COMPASS,

to measure inaccessible distances.

Having fixed the instrument to the stand, place it over the station-point, spreading the legs so as to give sufficient firmness, and observing that the card is level enough to allow it to play freely; raise the prism by means of the slide, until the divisions of the compass-card are distinctly seen; then look through the slit, and turn the box round until the thread bisects the object whose distance is required; allow the card to settle, and the division on it, which coincides with the thread of the vane, will be the azimuth, or bearing of the object,

reckoned from the north; or south point of the needle, when the card is divided into twice 180 degrees. The angular distance between any two objects will, of course, be the difference of their bearings; thus, suppose one to bear 15° N.E., and the other 165° S.E., the angular distance between them will be 150°.

In military sketching, the compass is often supported merely by the hands; using the little spring to check the vibrations of the card. In windy weather, the mean of these vibrations must be taken for the bearing sought.

The directions for Surveying, &c., &c., by means of "The Reconnoitring protractor," apply similarly to the "Prismatic compass."

4. BY MEANS OF "THE RECONNOITRING PROTRACTOR," *to ascertain the distance from inaccessible objects.**

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig.* 6.]

Select a good position for a base line; fix the protractor on the tripod at the first station, placing the instrument in a direct line between the first station and the point selected for the second station. Direct the index consecutively at the objects, the relative distances of which are to be ascertained, and note correctly their respective angles. When the object is above the horizontal line, the sliding-sight must be sufficiently raised to take its bearing; and, should the object be below the level of the protractor, its angle may be taken by observation through the upper holes of the near sight; or the feet of the tripod may be adjusted, by raising, or sinking them in the ground, so that the index may be correctly directed to the object. Then proceed to the

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* 1. The Reconnoitring protractor is not intended to supply the place of the Theodolite, or other expensive instruments, when very great accuracy is required in surveying, or in trigonometrical observations; but, in the hands of officers accustomed to the use of it, bearings may be rapidly taken, heights and distances ascertained, roads traversed, &c., &c., with sufficient accuracy for a military survey, or reconnoissance.

The protractor has a tripod, on which it is to be steadily fixed for taking angles, &c.; but the instrument can nevertheless be used without the tripod; and mounted officers may, after a little practice, make a reconnoissance with the protractor alone, especially if they are able to measure, or calculate the distance of base lines, by the length of the paces of their horses.

2. A survey, &c., may be very rapidly taken in the field, by laying drawing-paper on the face of the protractor, under the marginal scale, fixing it firmly by means of drawing-pins in the sides, and using, at the first station, the edge of the index as a ruler to set off on the paper, at once, by observation through the sights, the angles of the objects whose distance is required; drawing a base line parallel to the tube side of the instrument, and also lines at the angles found. At the second station, the paper must be moved a few inches towards the first station, and the index is to be directed to the objects, as before, and lines are to be produced until they intersect those drawn at the first station: thus the position of the objects will be obtained; and, by using the scale on the index for the length drawn for the measured base line, as well as for the lines directed to the objects, their respective distances will be ascertained.

3. The Reconnoitring protractor (invented by Major Griffiths, R.A.), and all other instruments for surveying, &c., &c., can be readily obtained from Messrs. Elliott, 30, Strand, London.

second station, measuring, or carefully pacing the base line, at the end of which fix the protractor in a straight line between the two stations; direct the index at the objects previously noted at the first station, taking their respective angles as before.

Construction—

Draw the base of the length required, according to the scale; from each end of which set off the angles found, and draw the lines required; the intersection of these will determine the position of the several objects, and their relative distances may be ascertained by measurement on the scale of the base line; or they may be calculated trigonometrically.

5.—BY MEANS OF TWO PICKETS,

to ascertain the distance from an object.

Take two pickets of unequal lengths, drive the shortest into the ground, say close to the edge of a river; measure some paces back from it, and drive in the other, till you find, by looking over the tops of both, that your sight cuts the opposite bank. Pull up the first picket, measure the same distance from the second in any direction the most horizontal, and drive it as deep in the ground as before. Then, if you look over them again, and observe where the line of sight falls, or terminates, you will have the distance required. This method is only applicable to short distances.

6.—*To ascertain the distance of the object* A *from* B.

[*Vide Plate* 2, *Fig.* 3.]

Place a picket at B, and another at C at a few yards' distance, making A B C a right angle, or B C perpendicular to A B.* Divide B C into 4, 5, or any number of equal parts, making another similar angle at C in a direction from the object, and walk along the line C D until you bring yourself in a line with the object A, and any of the divisions (say O) of the line B C. Then (having measured C D)

As C O : C D : : B O : B A.
Or, as 10 : 53 : : 30 : 159 yards.

7.—*To find the distance between two objects*, C, *and* D.

[*Vide Plate* 2, *Fig.* 4.]

From any point A, taken in the line C D, erect the perpendicular A E, on which set off from A to E 40 yards, set off from E to G, in the prolongation of A E, 10 yards, at G, raise the perpendicular G F, and produce it towards I, plant pickets at E, and G, then move with another picket

* To erect a perpendicular, *vide* "Practical Geometry."

on G F, till F is in a line with E, and D; and on the prolongation of the perpendicular F G place another picket at I in the line with E, and C: measure F I (54 yards), then—

as G E : A E : : F I : C D;

Or, as 10 : 40 : : 54 : 216 yards.

8.—*To find the inaccessible length,* A, B, *of the front of a fortification.*

[*Plate* 2, *Fig.* 5.]

Plant a picket at C, from whence both points may be seen; find the lengths C A, C B (by the method in No. 5); make C E one-fourth, or any part of C B, and make C D bear the same proportion to C A: measure D E; then

as C D : D E : : C A : A B.

Nearly in the same manner the distance from B to A may be ascertained, when the point B is accessible; for having measured the line C B, and made the angle C E D equal to C B A, the proportion will be as C E : D E : : C B : B A.

9.—BY MEANS OF THE TANGENT SCALE OF A GUN,

to ascertain the distance, the height of the object at the required distance being known.

Lay the gun by the line of metal for the top of the object; then raise the tangent scale till the top of it and the notch on the muzzle are in line with the foot of the object, and note what length of scale is required.

Then,—by similar triangles—

As the length of the raised part of the tangent scale
is to the length of the gun;
so is the height of the distant object
to the distance required.

Thus, supposing the height of the object to be 9 feet, the length of that part of the tangent scale which is raised, 3 inches, and of the gun 6 feet, the proportion will be—

As 3 : 72 : : 108 : 2592 inches, or 216 feet.

10.—BY MEANS OF THE PEAK OF A CAP,

to measure the breadth of a river.

Place yourself at the edge of one bank, and lower the peak of your cap till you find the edge of it cut the other bank, then steady your head by placing your hand under your chin, and turn round gently to some level spot of ground on your side of the river, and observe where your eyes and the edge of the peak again meet the ground; measure the distance, which will be *nearly* the breadth of the river.

11.—BY THE REPORT OF FIRE-ARMS, TO ASCERTAIN THE DISTANCE OF ANY OBJECT, *vide* SOUND, *page* 397.

12.—BY EYE-SIGHT, *to estimate distances, in the field.*

Good eye-sight recognises masses of troops at 1700 yards; beyond this distance the glitter of arms may be observed. At 1300 yards infantry may be distinguished from cavalry, and the movement of troops may be seen; the horses of cavalry are not, however, quite distinct, but that the men are on horseback is clear. A single individual detached from the rest of the corps may be seen at 1000 yards, but his head does not appear as a round ball until he has approached up to 700 yards; at which distance white cross-belts, and white trousers may be seen. At 500 yards the face may be observed as a light coloured spot; the head, body, arms, and their movements, as well as the uniform, and the firelocks (when bright barrels) can be made out. At between 200 and 250 yards all parts of the body are clearly visible, the details of the uniform are tolerably clear, and the officers may be distinguished from the men.

Vide "UNITED SERVICE MAGAZINE."—No. CCCXXXI.

BY MEANS OF THE RECONNOITRING PROTRACTOR,

to traverse roads.

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig.* 5.]

Fix the protractor on the tripod at the first station, placing it so that the side tube may be in a direct line with the intended second station. From each end of the tube observe the objects in sight (or place pickets) in order to secure a straight line in pacing, or measuring, from the first to the second station. Mark the distance between the stations, and place the protractor, by means of the tube, in a direct line with the first station. Then select the third station, and direct the arm or index correctly to it (using the upper holes of the near sight for a declivity, or raising the sliding sight for an ascent); note the angle thus found, and notice the objects in front, and rear (if any, if not, place pickets) for points to enable you to pace towards, and work with accuracy at the third station. Select station 4, place the tube in line with the third and second stations; note the bearing of No. 4, and pace the distance to it. Proceed thus from station to station, entering the angles and distances in your note-book, as well as the offsets (which must also be carefully measured) from the lines taken, until the survey is completed.

The traversing may be performed in a similar manner with the prismatic compass, &c.

Construction—

The day's work will be easily plotted on paper, by setting off the *angles* found, and drawing lines for the measured distances, according *to scale.*

SOUND.

The movement communicated to the particles of air by the vibrations of a sonorous body is the cause of the sensation of sound; and it is because the particles are driven from the point of vibration in every direction, as from a centre, that the sound is perceived at once, everywhere within the surface of a sphere of a certain extent.

The velocity of sound, or the space through which it is propagated in a given time, has been differently estimated by authors who have written on this subject. Roberval states it to be at the rate of 560 feet in a second; Gassendus at 1473; Mersenne at 1474; Duhamel at 1338; Newton at 960; Derham, in whose measure Flamsteed and Halley acquiesce, at 1142. By accounts in the Memoirs of the Royal Academy of Sciences, at Paris, 1738, when cannon were fired at various distances, under many varieties of weather, wind, and other circumstances, and where the measures of the different places had been settled with the utmost exactness, it was found that sound was propagated on a medium, at the rate of 1038 French feet in a second of time, which is equivalent to 1107 *English feet*, the French foot being in proportion to the English as 15 to 16.

From various experiments made with great care by Dr. O. Gregory, it has been found that sound flies through the air uniformly at the rate of about 1100 feet per second, when the air is quiescent, and at a medium temperature. At the temperature of freezing, or a little below, the velocity is about 1120. The approximate velocities under different temperatures may be found by adding to 1100 *half a foot* for every degree on Fahrenheit's thermometer above the freezing point. The mean velocity may be taken at 370 yards per second, or a mile in $4\frac{7}{9}$ seconds. Hence, multiplying any time employed by sound in moving by 370, will give the corresponding space in yards, or dividing any space in yards by 370 will give the time which sound will occupy in passing uniformly over that space. If the wind blow briskly, as at the rate of 20 to 60 feet per second, in the direction in which the sound moves, the velocity of the sound will be proportionally augmented; if the direction of the wind is opposed to that of the sound, the difference of their velocities must be employed. The velocity of sound is not affected by its intensity, the smallest sound moving as rapidly as the loudest.

*To ascertain the distance of any object by the report of fire-arms.**

Multiply the number of seconds which elapse between the time of seeing the flash, and hearing the report by 1100, and the product will be the distance in feet, with sufficient accuracy for ordinary purposes. If greater accuracy be required, this rule must be modified, on account of the velocity, and direction of the wind, and state of the thermometer.

Sound will be louder in proportion to the condensation of the air.

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* *Vide* page 396.

Water is one of the greatest conductors of sound; it can be heard on water nearly twice as far as upon land.

RECONNOITRING.*

The following *Memoranda* will serve to point out the principal objects to which an officer employed on the important duty of Reconnoitring should direct his attention.

1. *The particular nature of each district, &c., of country; and its productions.*

Information should be obtained, and noted on the following subjects. What parts of the country are mountainous, or hilly, and what are level; whether the hills are steep, broken by rocky ground, rise by gradual and easy slopes, or if the ground is undulated only in gentle swells. In what directions the ridges run, and which are their steepest sides. The nature and extent of their valleys, ravines, where they originate, in what direction they run, whether difficult of access, or to be easily passed. Whether the country is barren, or cultivated, and what is the kind of cultivation. If a country of pasturage, whether it is grazed by cattle, by sheep, or by horses, and in what numbers; what parts of the country are open, and what are enclosed, and the description of the enclosures. What parts of the country are wooded, and with what species of trees. What the nature of the soil. What is the nature of the country, in reference to the operations of troops, what parts of it are favourable for the acting of cavalry, and what for infantry only.

2. *The rivers, minor streams, and canals.*

The sources of *Rivers*, and the directions of their course, whether they are rapid, or otherwise; their breadth and depth and what variations they are subject to, at different seasons of the year; the nature of their channels, and of their banks, whether rocky, gravelly, sandy, or muddy; of easy, or of difficult access.

Bridges.

The Bridges across rivers whether of stone or of wood, their breadth, and length; if accessible to Artillery, and capable of bearing its weight. The nature of the *Fords*, if always passable, or at certain times, and seasons only; whether their situations change (a ford should not exceed, in depth, 3 feet for infantry, 4 feet for cavalry, and 2½ feet for artillery). What rivers are navigable, and from and to what points, and by what description of vessels, or boats.

Ferries.

Their breadth, and the nature of their landing-place on each side;

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* Extracted from "A Treatise on Military Surveying, including Sketching in the Field, Plan Drawing, Levelling, Military Reconnoissance, &c.," by Lieut.-Colonel Basil Jackson.

what description of boats are used on them, how many men, horses, or carriages, each boat is capable of conveying, how much time the passage requires, and in what manner it is performed.

Canals.

Their course, breadth, and depth, the nature of the traffic carried on upon them, the number of the boats usually to be found at different places, and the nature and dimensions of the boats, &c., navigated.

Lakes, and islets of the sea.

Their situation, extent, and boundaries, what description of vessels can navigate them, &c.

Marshes.

Their situation, and extent, whether passable for troops in any part: and if they continue throughout the year, or exist only during the wet season.

3. *Population, resources, accommodations for troops, &c.*

The size of towns, and villages, and the number of their inhabitants, and whether well supplied with provisions, or not. The number of houses, churches, convents, or other public buildings, whether the houses are large, or small, what number of troops could be accommodated in private houses, and what in public buildings; what stabling there is, or other cover for horses; if the town is walled, or open, favourably situated for defence, or otherwise; if capable of being strengthened, and by what means. Plans, or sketches of walled towns, defensible villages, or detached buildings should always accompany the reports upon them. The number of carriages, horses, mules, and draught oxen in possession of each town, village, &c., should be stated, and what mills are in the town, or vicinity, and whether turned by wind, or water, what number of bakehouses, and quantity of bread they can produce in a given time; whether the place is unhealthy, or not; if it be, whether it is in general unhealthy, or only so at particular seasons.

Roads.

Particular information must be obtained respecting the roads, in the description of which it is impossible to be too minute. Whether the road is fit for Artillery, wheel carriages, Cavalry, or for Infantry only, over what description of soil it passes, and to what injuries it is liable in bad weather: whether it is easily repairable, or not; whether materials are to be found in the neighbourhood, whether any great improvement can be made in the general direction of any part of the road, by adopting a new line, &c. Particular attention should be paid to the ascents and descents upon the road, whether they are gradual or abrupt, rugged or stony, having short turns, or other difficulties. The ferries, bridges, fords, &c., met with upon the road should be particularly described: the possibility of obstructing, or breaking up the road so as to prevent its being used by the enemy, or

of destroying the bridges or fords should be stated. The distances of the places along the road should be given, both in the measures of the country, and in English miles. The time required to travel the different distances (at the ordinary walk of a man, or pace of a horse) should also be stated. The places to the right, and left, near the road, should be mentioned; their distances from the road, and at what points the communications to them strike off. Whether there are any railroads, and what facilities they offer for the rapid transport of troops, artillery, provisions, &c.

Camps, and Positions.

All strong passes, posts, or more extensive positions, which present themselves either upon the line of a road, or in any other situation, as also all places favourable for encamping or bivouacking troops, should be particularly described, their situation, extent, facility of access, nature of soil, supply of water at all seasons, quantity and kind of wood, &c.

A sketch of the ground should always accompany these reports. Sketches of positions should never be made upon a smaller scale than four inches to an English mile. More general sketches may be made upon a scale of two inches to a mile, and tracings of roads upon a scale of one inch to a mile. In all Reports, officers should state distinctly what parts of the information they contain rest upon their own personal examination of the objects in question, and what upon the authority of others, and in the latter case, they should mention the source of their information.

THE END.

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